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LIQUID AND GASEOUS OXYGEN SAFETY REVIEW

FINAL REPORT

Vol. III

JUNE 1972

A. LAPIN
AIR PRODUCTS AND CHEMICALS, INC.
ALLENTOWN, PENNSYLVANIA 18105

Prepared for

AEROSPACE SAFETY RESEARCH AND DATA INSTITUTE
LEWIS RESEARCH CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CLEVELAND, OHIO 44135

Under

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16. Abstract

A thorough and detailed study of Air Products and Chemicals, Inc. and Air Products Ltd. practices in the design and use of equipment in oxygen service, was performed. The report includes Liquid and Gaseous Oxygen Safety Review information covering: Material Compatibility, Operational Hazards, Maintenance Programs, Systems Emergencies, and Accident/Incident Investigations and Reports, and a set of references. Areas requiring further research and development for systems involving exposure to oxygen environment have been identified. An index to the Liquid and Gaseous Safety Review Data Forms and a General Index have been included to allow for easy retrieval of the reported information.

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Volume III of Four Volumes

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Allentown, Pennsylvania 18105

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Air Products and Chemicals INC.

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PRESSURE RATING TABLES - PLAIN ENDS - COPPER TUBE

1. PURPOSE

This standard provides the Maximum Allowable Pressures for copper tube.

2. SCOPE

This standard encompasses copper tube made according to ASTM specifications B75 and B88.

3. MATERIAL SPECIFICATION

The following material specifications apply to the tube described herein:

A.	MATERIAL DESCRIPTION	NOMINAL SIZE RANGE
(1)	TUBE SMLS CU ASTM B75	1/4" thru 1/2"
(2)	TUBE SMLS CU ASTM B88	3/4" and up

4. ALLOWABLE STRESS VALUE

The allowable stress values for the materials described in this standard are based on ASA B31.3 1959 American Standard Code for Pressure Piping, Section 3, Petroleum Refinery Piping, Table 302.3.1A. The allowable stress values are based on copper tube at 100°F and 150°F.

A.	MATERIAL DESCRIPTION	ALLOWABLE STRESS VALUE
(1)	TUBE SMLS CU ASTM B75	6,000 PSI
(2)	TUBE SMLS CU ASTM B88	6,000 PSI

5. MAXIMUM ALLOWABLE PRESSURE

The maximum allowable pressure for the tube is based on the following formula from ASA B31.3 1959 American Standard Code for Pressure Piping, Section 3, Petroleum Refinery Piping, Para. 304.1.2.

A. Formula.

$$P = \frac{2S\,(t_m - C)}{D - 0.8(t_m - C)}$$

P = Maximum Allowable Pressure, PSI
S = Maximum Allowable Hoop Stress from 4A
D = O.D. of tube as listed in standard tube specification.
t_m = Minimum Wall thickness as specified by above code.
C = 0.0 for plain end tube

APCI DOCUMENT NO 99000161

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PRESSURE RATING TABLES - PLAIN ENDS - COPPER TUBE

TYPE	O.D.	NOM. SIZE	NOM. WALL (t)	MIN. WALL (t_m)	MAX. PSI	LBS. PER FT.	MATERIAL CODE NUMBER
	3/8"	1/4"	.065	.0615	2330	.245	1-894-13-0020
	5/8"	1/2"	.065	.0615	1280	.443	1-894-13-0040
K	7/8"	3/4"	.065	.0605	943	.641	1-893-13-0050
L			.045	.041	586	.455	1-893-13-0045
M			.032	.0305	433	.328	1-892-13-0007
K	1 1/8"	1"	.065	.0605	674	.839	1-893-13-0060
L			.050	.046	507	.655	1-893-13-0055
M			.035	.0315	345	.465	1-892-13-0009
K	1 3/8"	1 1/4"	.065	.0605	546	1.04	1-893-13-0070
L			.055	.0505	454	.844	1-893-13-0065
M			.042	.0385	343	.682	1-892-13-0011
K	1 5/8"	1 1/2"	.072	.067	511	1.36	1-893-13-0080
L			.060	.0555	421	1.14	1-893-13-0075
M			.049	.045	339	.940	1-892-13-0013
K	2 1/8"	2"	.083	.076	442	2.06	1-893-13-0090
L			.070	.064	370	1.75	1-893-13-0085
M			.058	.052	299	1.46	1-892-13-0015
K	2 5/8"	2 1/2"	.095	.088	414	2.93	1-893-13-0100
L			.080	.074	346	2.48	1-893-13-0095
M			.065	.059	274	2.03	1-892-13-0017
K	3 1/8"	3"	.109	.102	402	4.00	1-893-13-0110
L			.090	.083	326	3.33	1-893-13-0105
M			.072	.066	258	2.68	1-892-13-0019
K	4 1/8"	4"	.134	.124	370	6.51	1-893-13-0130
L			.110	.101	300	5.38	1-893-13-0125
M			.095	.086	254	4.66	1-892-13-0023

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PRESSURE RATING TABLES - PLAIN AND THREADED ENDS - COPPER PIPE

1. PURPOSE

This standard provides the Maximum Allowable Pressures for copper pipe with plain and threaded ends.

2. SCOPE

This standard encompasses copper pipe made according to ASTM specification B42.

3. MATERIAL SPECIFICATION

The following material specification applies to the pipe described herein:

A.	MATERIAL DESCRIPTION	IPS SIZE RANGE
(1)	PIPE SMLS CU ASTM B42	1/8" thru 6"

4. ALLOWABLE STRESS VALUE

The allowable stress values for the materials described in this standard are based on ASA B31.3 1959 American Standard Code for Pressure Piping, Section 3, Petroleum Refinery Piping, Table 302.3.1A. The allowable stress values are based on copper pipe at 100°F and 150°F.

A.	MATERIAL DESCRIPTION	ALLOWABLE STRESS VALUE
(1)	PIPE SMLS CU ASTM B42	6,000 PSI

MAXIMUM ALLOWABLE PRESSURE

The maximum allowable pressure for the pipe is based on the following formula from ASA B31.3 1959 American Standard Code for Pressure Piping, Section 3, Petroleum Refinery Piping, Para. 304.1.2.

A. Formula:

$$P = \frac{2S\,(t_m - C)}{D - 0.8\,(t_m - C)}$$

P = Maximum Allowable Pressure, PSI
S = Maximum Allowable Hoop Stress, from 4A
D = O.D. of pipe as listed in standard pipe specification
t_m = Minimum Wall thickness as specified by above code.
C = 0.0 for plain end pipe
C = Depth of thread or 0.05 whichever is greater.

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DESIGN ENGINEERING STANDARDS

570 PIPING

PRESSURE RATING TABLES - PLAIN ENDS - COPPER PIPE

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX PSI	LBS. PER FT.	MATERIAL CODE NUMBER
Std.	1/8"	.405	.062	.0589	1942	.259	1-580-13-0001
XH			.100	.095	3464	.371	1-580-13-0014
Std.	1/4"	.540	.082	.0779	1957	.457	1-580-13-0002
XH			.123	.1168	3138	.625	1-580-13-0015
Std.	3/8"	.675	.090	.0855	1691	.641	1-580-13-0003
XH			.127	.1206	2501	.847	1-580-13-0016
Std.	1/2"	.840	.107	.1016	1606	.955	1-580-13-0004
XH			.149	.1415	2336	1.25	1-580-13-0017
XXH			.294	.2793	5435	1.95	1-580-13-0027
Std.	3/4"	1.050	.114	.1083	1349	1.30	1-580-13-0005
XH			.157	.1491	1922	1.71	1-580-13-0018
XXH			.308	.2926	4303	2.78	1-580-13-0028
Std.	1"	1.315	.126	.1197	1178	1.82	1-580-13-0006
XH			.182	.1729	1763	2.51	1-580-13-0019
XXH			.358	.3401	3913	4.17	1-580-13-0029
Std.	1 1/2"	1.900	.150	.1425	957	3.20	1-580-13-0008
XH			.203	.1928	1325	4.19	1-580-13-0021
XXH			.400	.380	2857	7.31	1-580-13-0031
Std.	2"	2.375	.156	.1482	788	4.22	1-580-13-0009
XH			.221	.2099	1141	5.80	1-580-13-0022
XXH			.436	.4142	2432	10.3	1-580-13-0032
Std.	2 1/2"	2.875	.187	.1776	779	6.12	1-580-13-0010
XH			.280	.266	1197	8.85	1-580-13-0023
XXH			.552	.5244	2562	15.6	1-580-13-0033
Std.	3"	3.500	.219	.208	749	8.75	1-580-13-0011
XH			.304	.2888	1060	11.80	1-580-13-0024
XXH			.600	.570	2246	21.2	1-580-13-0034
Std.	4"	4.50	.250	.2375	661	12.90	1-580-13-0012
XH			.341	.3239	916	17.30	1-580-13-0025
XXH			.674	.6403	1926	31.4	1-580-13-0035
Std.	6"	6.625	.250	.2375	442	19.40	1-580-13-0013
XH			.437	.4151	791	32.90	1-580-13-0026
XXH			.864	.8208	1650	60.6	1-580-13-0036

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PRESSURE RATING TABLES - THREADED ENDS - COPPER PIPE

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX PSI	LBS. PER FT.	MATERIAL CODE NUMBER
Std.	1/8"	.405	.062	.0589	269	.259	1-580-13-0001
XH			.100	.095	1463	.371	1-580-13-0014
Std.	1/4"	.540	.082	.0779	646	.457	1-580-13-0002
XH			.123	.1168	1647	.625	1-580-13-0015
Std.	3/8"	.675	.090	.0855	659	.641	1-580-13-0003
XH			.127	.1206	1370	.847	1-580-13-0016
Std.	1/2"	.840	.107	.1016	663	.955	1-580-13-0004
XH			.149	.1415	1310	1.25	1-580-13-0017
XXH			.294	.2793	4026	1.95	1-580-13-0027
Std.	3/4"	1.050	.114	.1083	609	1.30	1-580-13-0005
XH			.157	.1491	1130	1.71	1-580-13-0018
XXH			.308	.2926	3279	2.78	1-580-13-0028
Std.	1"	1.315	.126	.1197	472	1.82	1-580-13-0006
XH			.182	.1729	1006	2.51	1-580-13-0019
XXH			.358	.3401	2955	4.17	1-580-13-0029
Std.	1 1/2"	1.900	.150	.1425	475	3.20	1-580-13-0008
XH			.203	.1928	821	4.19	1-580-13-0021
XXH			.400	.3800	2755	7.31	1-580-13-0031
Std.	2"	2.375	.156	.1482	408	4.22	1-580-13-0009
XH			.221	.2099	744	5.80	1-580-13-0022
XXH			.436	.4142	1970	10.3	1-580-13-0032
Std.	2 1/2	2.875	.187	.1776	331	6.12	1-580-13-0010
XH			.280	.266	726	8.85	1-580-13-0023
XXH			.552	.5244	2009	15.6	1-580-13-0033
Std.	3"	3.500	.219	.208	380	8.75	1-580-13-0011
XH			.304	.2888	677	11.80	1-580-13-0024
XXH			.600	.570	1806	21.2	1-580-13-0034
Std.	4"	4.50	.250	.2375	376	12.80	1-580-13-0012
XH			.341	.3239	622	17.30	1-580-13-0025
XXH			.674	.6403	1594	31.4	1-580-13-0035
Std.	6"	6.625	.250	.2375	254	19.40	1-580-13-0013
XH			.437	.4151	594	32.90	1-580-13-0026
XXH			.864	.8208	1430	60.6	1-580-13-0036

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COLD BOX SERVICE +100°F & BELOW 200 PSIG MAX OWG COPPER TUBE

ITEM	DESCRIPTION			SPECIFICATION
TUBING, SEAMLESS, COPPER, DRAWN DHP, B75 STRAIGHT				
NOM. SIZE	O.D.	NOM. WALL	TYPE	MATERIAL CODE NUMBER
	3/8"	.065		1-894-13-0020
	5/8"	.065		1-894-13-0040
TUBING, SEAMLESS, COPPER, BENDING TEMPER, B88 STRAIGHT				
3/4"	7/8"	.045	L	1-893-13-0045
1"	1 1/8"	.050	L	1-893-13-0055
1 1/4"	1 3/8"	.055	L	1-893-13-0065
1 1/2"	1 5/8"	.060	L	1-893-13-0075
2"	2 1/8"	.070	L	1-893-13-0085
2 1/2"	2 5/8"	.080	L	1-893-13-0095
3"	3 1/8"	.090	L	1-893-13-0105
3 1/2"	3 5/8"	.100	L	1-893-13-0115
4"	4 1/8"	.110	L	1-893-13-0125
FITTINGS				
1/4" thru 4"		Wrot Copper, Solder Ends		ASTM B75 ASA B16.22
UNIONS				
1/4" thru 2"		Wrot Copper, Gr. Joint, Brz. to Brz. Seat, Solder Ends		ASA B16.22
FLANGES		See Note # 5		
VALVES				
GATE				
1/4" thru 2"		200# Cast Brz., Screwed		V-11A

APCI DOCUMENT NO. 22222/62

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COLD BOX SERVICE +100°F & BELOW 200 PSIG MAX OWG COPPER TUBE

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
GATE		
1/4" thru 3"	200# Cast Brz., Solder Ends	V-11D
1/4" thru 3"	Same - Extended Bonnet	EBV-11D
4"	150# Cast Brz., Solder Ends	V-4D
4"	Same - Extended Bonnet	EBV-4D
GLOBE		
1/4" thru 2"	200# Cast Brz., Screwed	V-511A
1/4" thru 3"	200# Cast Brz., Solder Ends	V-512D
1/4" thru 3"	Same - Extended Bonnet	EBV-512D
ANGLE		
1/4" thru 2"	200# Cast Brz., Screwed	V-1011A
1/4" thru 3"	200# Cast Brz., Solder Ends	V-1011D
1/4" thru 3"	Same - Extended Bonnet	EBV-1011D
CHECK		
1/4" thru 3"	125# Cast Brz., Solder Ends	V-1501D
GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	400# OWG Cast Brz., Needle Type, Screwed Ends (Warm Zone Only)	V-2011A

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COLD BOX SERVICE +100°F & BELOW 200 PSIG MAX CWG COPPER TUBE

NOTE:

1. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 4". For detail bend radius data see Design Engr. Std. 574.1.1.

2. Valves with a designator prefix of EBV - are Extended Bonnet Valves. These valves are to be selected from Air Products and Chemicals, Inc. Design Engineering Standards Section 579.4.

3. The term "Solder" shall, in all cases, be interpreted as referring to the use of silver braze.

4. Wrought copper caps may be used only up to 1/2".

5. Flanges are to be avoided if possible. If they are necessary, they are to be selected from Air Products and Chemicals, Inc. Design Engineering Standard 579.2.4.

   A. For LOX, liquid or gaseous H_2, liquid or gaseous argon, liquid or gaseous methane or any other hazardous or valuable material, use 300# minimum flange rating in sizes 3" and below.

   B. 150# flange rating may be used where called for in piping standards for joints 4" and over regardless of fluid, and for 3" and below for fluids and conditions not covered in (5, A.).

6. This standard can be used for temperatures above 100°F. To determine the maximum PSI for elevated temperatures, the following conversion factors may be applied to the values shown in the Pressure Rating Tables (ASA B31.1, Section 2, Table 4).

150°F - 1.000	350°F - .750
250°F - .833	400°F - .500

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COLD BOX SERVICE +100°F & BELOW 400 PSIG MAX OWG COPPER TUBE

ITEM		DESCRIPTION		SPECIFICATION
TUBING, SEAMLESS, COPPER, DRAWN, DHP, B75 STRAIGHT				
NOM. SIZE	O.D.	NOM. WALL	TYPE	MATERIAL CODE NUMBER
	3/8"	.065		1-894-13-0020
	5/8"	.065		1-894-13-0040
TUBING, SEAMLESS, COPPER, BENDING TEMPER, B88 STRAIGHT				
3/4"	7/8"	.045	L	1-893-13-0045
1"	1 1/8"	.050	L	1-893-13-0055
1 1/4"	1 3/8"	.055	L	1-893-13-0065
1 1/2"	1 5/8"	.060	L	1-893-13-0075
FITTINGS				
1/4" thru 1 1/2"		Wrot Copper, Solder Ends		ASTM B75 ASA B16.22
UNIONS				
1/4" thru 1 1/2"		Wrot Copper, Gr. Joint to Brz. Seat, Solder Ends		ASA B16.22
FLANGES		See Note # 5		
VALVES				
GATE				
1/4" thru 1 1/2"		200# Cast Brz., Screwed		V-11A
1/4" thru 1 1/2"		200# Cast Brz., Solder Ends		V-11D
1/4" thru 1 1/2"		Same - Extended Bonnet		EBV-11D
GLOBE				
1/4" thru 1 1/2"		200# Cast Brz., Screwed		V-511A
1/4" thru 1 1/2"		200# Cast Brz., Solder Ends		V-512D
1/4" thru 1 1/2"		Same - Extended Bonnet		EBV-512D

APCI DOCUMENT NO. 9000163

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COLD BOX SERVICE +100°F & BELOW 400 PSIG MAX OWG COPPER TUBE

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
ANGLE		
1/4" thru 1 1/2"	200# Cast Brz., Screwed	V-1011A
1/4" thru 1 1/2"	200# Cast Brz., Solder Ends	V-1011D
1/4" thru 1 1/2"	Same - Extended Bonnet	EBV-1011D
CHECK		
1/4" thru 1 1/2"	200# Cast Brz., Solder Ends	V-1511D
GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	400# OWG Bronze, Needle Type, Screwed Ends (Warm Zone Only)	V-2011A

NOTE:
1. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 4". For detail bend radius data see Design Engr. Std. 574.1.1.
2. Valves with a designator prefix of EBV - are Extended Bonnet Valves. These valves are to be selected from Air Products and Chemicals, Inc. Design Engineering Standards Section 579.4.
3. The term "Solder" shall, in all cases, be interpreted as referring to the use of silver braze.
4. Wrought copper caps may not be used at all.
5. Flanges are to be avoided if possible. If they are necessary, they are to be selected from Air Products and Chemicals, Inc. Design Engineering Standard 579.2.4 - 15 thru 579.2.4 - 26.
6. This standard can be used for temperatures above 100°F. To determine the maximum PSI for elevated temperatures, the following conversion factors may be applied to the values shown in the Pressure Rating Tables - Design Engineering Standard 574.1 (ASA B31.1, Section 2, Table 4).

150°F - 1.000	350°F - .750
250°F - .833	400°F - .500

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COLD BOX SERVICE
PROCESS (INSTRUMENT PIPING) 100°F & BELOW, 400 PSIG MAX OWG COPPER TUBE

ITEM	DESCRIPTION	SPECIFICATION
INSIDE COLD BOX		
TUBING	3/8" O.D. Copper (0.030" Wall) Type L	ASTM B88, Annealed, Straight
	or	
	3/8" O.D. Copper (0.030" Wall) Type L (Coiled tube shall not be used in APCI Shop-manufactured Cold Boxes)	ASTM B88, Annealed, Coiled
(For Analyzer Taps)	3/8" O.D. Copper (0.065" Wall) (0.065" Wall is mandatory for Analyzer Taps)	ASTM B75 DHP Drawn, Straight
FITTINGS		
ELLS	None (use bends)	
COUPLING	3/8" O.D. x 3/8" O.D. Brass Union, Flareless Type, Swagelok, Gyrolok, or Parker C.P.I.	
	or	
	3/8" O.D. Wrot Copper, Solder Ends	ASTM B75 ASA B16.22
ADAPTER (At STSTL Line)	3/8" O.D. x 1/4" IPS, Type 316 STSTL Buttweld Male Connector to Flareless Joint, Swagelok, Gyrolok, or Parker C.P.I.	
ADAPTER (At Aluminum Line)		
COUPLING	1/2" FNPT 2000# Forged Aluminum Coupling or Thredolet	ASTM B247 6061-T6 ASA B16.11
CONNECTOR	3/8" O.D. 1/2" MNPT, Brass Male Connector, Flareless Type, Swagelok, Gyrolok, or Parker C .I.	
OUTSIDE COLD BOX		
ADAPTER (At Jacket)	3/8" O.D. x 1/4" FNPT, Brass Bulkhead Female Connector, Flareless Type, Swagelok, Gyrolok, or Parker C.P.I.	

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Date Nov. 1, 1968

APCI DOCUMENT NO 99000164

COLD BOX SERVICE
PROCESS (INSTRUMENT PIPING) 100°F & BELOW, 400 PSIG MAX OWG COPPER TUBE

ITEM	DESCRIPTION	SPECIFICATION
OUTSIDE COLD BOX (Cont'd.)		
ADAPTER (Cont'd.)	Steel, Bulkhead Retainer (For use with Bulkhead Female Connector), Swagelok, Gyrolok, or Parker C.P.I.	
NIPPLE	1/4" Brass Hex	Kerotest U-10 or Equal
FITTINGS	1/4" FNPT, 250# Cast Brass Screwed Ends	ASTM B62
VALVES		
Globe	1/4", 400# OWG, Bronze Screwed Ends	V-2011A

NOTE: 1. Ells shall not be used inside the cold box. Only bends are permitted.

2. Installation of flareless fittings shall be in strict accordance with manufacturer's instructions.

3. Before tightening external bulkhead nut, caulk bulkhead female connector with Dow-Corning Silastic '/32 RTV adhesive sealant to provide suitable jacket seal.

4. The term "Solder" shall in all cases be interpreted as referring to the use of silver braze.

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COLD BOX SERVICE
PROCESS (INSTRUMENT PIPING) 100°F & BELOW, 900 PSIG MAX OWG COPPER TUBE

ITEM	DESCRIPTION	SPECIFICATION
INSIDE COLD BOX		
TUBING	3/8" O.D. Copper (0.030" Wall) Type L	ASTM B88, Annealed Straight
	or	
	3/8" O.D. Copper (0.030" Wall) Type L (Coiled tube shall not be used in APCI Shop-manufactured Cold Boxes)	ASTM B88, Annealed Coiled
(For Analyzer Taps)	3/8" O.D. Copper (0.065" Wall) (0.065" Wall is mandatory for Analyzer Taps)	ASTM B75 DHP Drawn Straight
FITTINGS		
ELLS	None (use bends)	
COUPLING	3/8" O.D. x 3/8" O.D. Brass Union Flareless Type, Swagelok, Gyrolok, or Parker C.P.I.	
	or	
	3/8" ODFS, Brass, Solder Ends	APCI DWG. 41215A
ADAPTER (At STSTL Line)	3/8" O.D. x 1/4" IPS, Type 316 STSTL, Buttweld Male Connector to Flareless Joint, Swagelok, Gyrolok, or Parker C.P.I.	
ADAPTER (At Aluminum Line)		
COUPLING	1/2" FNPT 2000# Forged Aluminum Coupling or Thredolet	ASTM B247 6061-T6
CONNECTOR	3/8" O.D. x 1/2" MNPT, Brass Male Connector, Flareless Type, Swagelok, Gyrolok, or Parker C.P.I.	
OUTSIDE COLD BOX		
ADAPTER (At Jacket)	3/8" O.D. x 1/4" FNPT, Brass, Bulkhead Female Connector, Flareless Type, Swagelok, Gyrolok, or Parker C.P.I.	

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Date Nov. 1, 1968

APCI DOCUMENT NO 99000/165

COLD BOX SERVICE
PROCESS (INSTRUMENT PIPING) 100°F & BELOW, 900 PSIG MAX OWG COPPER TUBE

ITEM	DESCRIPTION	SPECIFICATION
OUTSIDE COLD BOX (Cont'd.)		
ADAPTER (Cont'd.)	Steel, Bulkhead Retainer (For use with Bulkhead Female Connector), Swagelok, Gyrolok, or Parker C.P.I.	
PIPE	1/4" Sch. 80S, Seamless, Threaded Ends	ASTM A312 Tp 304
FITTINGS	1/4" FNPT, 2000# Forged STSTL, Screwed Ends	ASTM A182 F304 ASA B16.11
VALVES		
Globe	1/4", 3000# OWG, Type 304 or 316 STSTL, Screwed Ends	V-719A

NOTE: 1. Ells shall not be used inside the cold box. Only bends are permitted.

2. Installation of flareless fittings shall be in strict accordance with manufacturer's instructions.

3. Before tightening external bulkhead nut, caulk bulkhead female connector with Dow-Corning Silastic 732 RTV adhesive sealant to provide suitable jacket seal.

4. The term "Solder" shall in all cases be interpreted as referring to the use of silver braze.

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COLD BOX SERVICE 100°F & BELOW 1000 PSIG MAX OWG COPPER TUBE
PROCESS (INSTRUMENT PIPING)

ITEM	DESCRIPTION	SPECIFICATION
INSIDE COLD BOX		
TUBING	3/8" O.D. Copper (0.065" Wall)	ASTM B75, No. 122 Bending Temper (Light Drawn), Straight
	PREFERRED SYSTEM	
INSIDE COLD BOX		
FITTINGS (See Note 1)		
ELLS(See Note 2)	1/4" MNPT x 3/8" O.D., Brass Male Elbow, Flareless Type, Swagelok, Gyrolok, or Parker C.P.I.	
COUPLING	3/8" ODFS - Brass	26748A
ADAPTER (At Process Source)	1/4" IPS x 3/8" ODFS ST STL	579.13.2 - 1
OUTSIDE COLD BOX		
PIPE NIPPLE	1/4" Sch. 80S, Seamless, Threaded Ends, ST STL	ASTM A312 Tp 304
FITTINGS	1/4" FNPT - 2000# Forged ST STL, Screwed Ends	ASTM A182 F 304 ANSI B16.11
ADAPTERS (At Jacket)	3/8" ODFS x 1/4" MNPT, ST STL	579.13.1 - 2
VALVES	1/4" - 3000#OWG, Globe, Type 304 or 316 ST STL	V-719A
	ALTERNATE SYSTEM	
INSIDE COLD BOX		
FITTINGS (See Note 1)		
ELLS (See Note 2)	1/4" MNPT x 3/8" O.D., Brass Male Elbow, Flareless Type, Swaglok, Gyrolok, or Parker C.P.I.	
COUPLINGS	3/8" O.D. x 3/8" O.D. Brass Union Flareless Type, Swagelok, Gyrolok, or Parker C.P.I.	

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Date 5/25/72
APCI DOCUMENT NO. 99000166

COLD BOX SERVICE 100°F & BELOW 1000 PSIG MAX OWG COPPER TUBE
PROCESS (INSTRUMENT PIPING)

INSIDE COLD BOX (Cont.)

ADAPTER (At ST STL Line)	3/8" O.D. x 1/4" IPS, Type 316 ST STL, Buttweld Male Connector to Flareless Joint, Swagelok, Gyrolok, or Parker C.P.I.	
ADAPTER (At Aluminum Line)		
COUPLING	1/4" FNPT 2000# Forged Aluminum Coupling or Thredolet	ASTM B247 6061-T6 ANSI B16.11
CONNECTOR	3/8" O.D. x 1/4" MNPT, Brass Male Connector, Flareless Type, Swagelok, Gyrolok, or Parker C.P.I.	

OUTSIDE COLD BOX

ADAPTER (See Fig 1) (At Jacket)	3/8" O.D. x 3/8" O.D., Brass, Bulkhead Union, Flareless Type, Swagelok, Gyrolok, or Parker C.P.I. and 3/8" O.D. x 1/4" MNPT, ST STL, Male Adapter, Flareless Type, Swagelok, Gyrolok, or Parker C.P.I. and Steel, Bulkhead Retainer (For use with Bulkhead Union), Swagelok, Gyrolok, or Parker C.P.I.	
PIPE NIPPLE	1/4" Sch. 80S, Seamless Threaded Ends, ST STL	ASTM A312 Tp 304
FITTINGS	1/4" FNPT, 2000# Forged ST STL, Screwed Ends	ASTM A182 F304 ANSI B16.11
VALVES	1/4", 3000# OWG, Globe, Type 304 or 316 ST STL, Screwed Ends	V-719A

Air Products and Chemicals INC.

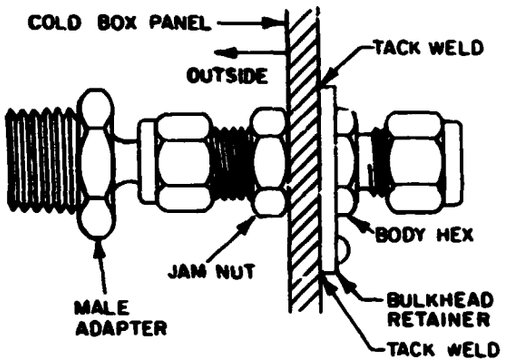
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COLD BOX SERVICE 100°F & BELOW 1000 PSIG MAX OWG COPPER TUBE
PROCESS (INSTRUMENT PIPING)

NOTE: 1. Installation of flareless fittings shall be in strict accordance with manufacturer's instructions.

2. Ell shall not be used inside the cold box except immediately adjacent to a vessel. See Design Engineering Standard 579.23 for instrument piping concept.

3. The term "Solder" shall in all cases be interpreted as referring to the use of silver braze.



Note: Before tightening jam nut, caulk around panel hole with Dow-Corning Silastic 732 RTV to obtain a jacket seal.

Figure 1. Bulkhead Union Installation Requirements

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Date 5/25/72

COLD BOX SERVICE +100°F & BELOW 2300 PSIG MAX CWG COPPER TUBE
PROCESS (INSTRUMENT PIPING)

ITEM	DESCRIPTION	SPECIFICATION
(INSIDE COLD BOX)		
TUBING	3/8" OD Copper (.065" Wall)	ASTM B75 DHP Drawn Straight
FITTINGS		
ELLS	None	
COUPLING	3/8" ODFS, Brass	41215A
ADAPTER	1/4" IPS x 3/8" ODFS STSTL	579.13.2 - 1
(OUTSIDE COLD BOX)		
PIPE	1/4" SCH. 80S, STSTL Seamless, Threaded Ends	ASTM A312 Tp 304
FITTINGS	1/4" FNPT - 3000# Forged STSTL, Screwed Ends	ASTM A182 F304
ADAPTERS (At Jacket)	3/8" ODFS x 1/4" MNPT STSTL	579.13.1 - 2
COUPLINGS (At Individual Local Instruments)	1/4" FNPT - 3000# Forged STSTL, Screwed Ends	ASTM A182 F304
	1/2" FNPT x 1/4" FNPT 3000# Forged STSTL, Screwed Ends	ASTM A182 F304
VALVES (At Individual Local Instruments)		
GLOBE	1/4" - 3000# CWG Type 304 Forged STSTL, Screwed Ends	V-719A

APCI DOCUMENT NO 99000462

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COLD BOX SERVICE +100°F & BELOW 2300 PSIG MAX OWG COPPER TUBE
PROCESS (INSTRUMENT PIPING)

ITEM	DESCRIPTION	SPECIFICATION
(OUTSIDE COLD BOX - Cont'd)		
ADAPTERS (At Local Panels) (When Pigtail Assy. is req'd)		
(At Jacket)	3/8" ODFS x 1/2" FNPT STSTL	54701A
(At Shut-Off Valves and at Gauges)	1/4" FNPT x .903" Std. O_2 Connection, Brass	28473A
(At Gauge)	1/2" FNPT x .903" Std. O_2 Connection, Brass	28698A
Pigtail Assembly	.903" Std. O_2 Connections, Copper	47358A
VALVES - Cylinder (For use with Pigtail Assy.)		
	1/2" MNPT x .903" Std. O_2 Connection - 4000# OWG Forged Brass, Screwed Ends	Superior AP1200X1

NOTE: 1. No ells are to be used inside the cold box. Only bends are permitted.

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PRESSURE RATING TABLES - PLAIN AND THREADED ENDS - CARBON STEEL PIPE

1. PURPOSE

This standard provides a maximum allowable pressure for carbon steel pipe with plain and threaded ends.

2. SCOPE

This standard includes carbon steel pipe made according to ASTM A53 Gr B Seamless and ASTM A53 Buttweld.

3. MATERIAL SPECIFICATION

The following material specifications apply to the pipe described herein:

MATERIAL DESCRIPTION	IPS SIZE RANGE
(1) PIPE SMLS CS ASTM A53 Gr B	1/8" and larger
(2) PIPE BW CS ASTM A53	1/8" thru 4"

4. ALLOWABLE STRESS VALUE

The allowable stress values for the materials described in this standard are based on ASA B31.1 - American Standard Code for Pressure Piping, Section 2, Industrial Gas and Air Piping Systems. The allowable stress values are based on carbon steel pipe at 100°F.

MATERIAL DESCRIPTION	ALLOWABLE STRESS VALUE
(1) PIPE SMLS CS ASTM A53 Gr B	21,000 PSI
(2) PIPE BW CS ASTM A53	9,000 PSI

5. MAXIMUM ALLOWABLE PRESSURE

The maximum allowable pressure for the pipe is based on the following formula from ASA B31.1 - American Code for Pressure Piping, Section 2, Industrial Gas and Air Piping Systems.

Formula:

$$P = \frac{2S\ (t_m - C)}{D - 0.8\ (t_m - C)}$$

P = Maximum allowable pressure - PSI
S = Maximum allowable hoop stress from above values
D = O.D. of pipe as listed in standard tables
t_m = Minimum wall thickness as specified by above code
C = 0.050 for welded joints. Depth of thread or 0.050, whichever is greater, for threaded joints.

APCI DOCUMENT NO. 22000168

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PRESSURE RATING TABLES - SEAMLESS, PLAIN ENDS - CARBON STEEL PIPE

6. PRESSURE RATING TABLES

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX. PSI	LBS. PER FT.	MATERIAL CODE NUMBER
Std. (40)	1/8"	.405	.068	.059	948	.25	1-548-67-0201
XH (80)			.095	.083	3660	.32	1-548-67-0202
Std. (40)	1/4"	.540	.088	.077	2187	.43	1-548-67-0205
XH (80)			.119	.104	4565	.54	1-548-67-0206
Std. (40)	3/8"	.675	.091	.079	1868	.57	1-548-67-0209
XH (80)			.126	.110	4019	.74	1-548-67-0210
Std. (40)	1/2"	.840	.109	.095	2350	.85	1-548-67-0214
XH (80)			.147	.128	4212	1.09	1-548-67-0215
160			.187	.164	6394	1.31	1-548-67-0217
XXH			.294	.257	12891	1.72	1-548-67-0216
Std. (40)	3/4"	1.050	.113	.099	2036	1.13	1-548-67-0220
XH (80)			.154	.134	3589	1.47	1-548-67-0221
160			.218	.190	6268	1.94	1-548-67-0223
XXH			.308	.269	10514	2.44	1-548-67-0222
Std. (40)	1"	1.315	.133	.116	2196	1.68	1-548-67-0226
XH (80)			.179	.156	3618	2.17	1-548-67-0227
160			.250	.218	5976	2.85	1-548-67-0229
XXH			.358	.313	10000	3.66	1-548-67-0228
Std. (40)	1 1/2"	1.900	.145	.127	1759	2.72	1-548-67-0238
XH (80)			.200	.175	2916	3.63	1-548-67-0239
160			.281	.246	4722	4.87	1-548-67-0241
XXH			.400	.350	7590	6.41	1-548-67-0240
Std. (40)	2"	2.375	.154	.134	1528	3.65	1-548-67-0244
XH (80)			.218	.190	2598	5.02	1-548-67-0245
160			.343	.300	4827	7.45	1-548-67-0246
XXH			.436	.381	6588	9.03	1-548-67-0247
Std. (40)	2 1/2"	2.875	.203	.177	1923	5.79	1-548-67-0251
XH (80)			.276	.242	2963	7.66	1-548-67-0252
160			.375	.328	4401	10.01	1-548-67-0253
XXH			.552	.483	7192	13.70	1-548-67-0254
Std. (40)	3"	3.500	.216	.189	1722	7.58	1-548-67-0258
XH (80)			.300	.262	2673	10.25	1-548-67-0259
160			.438	.383	4325	14.30	1-548-67-0260
XXH			.600	.525	6394	18.58	1-548-67-0261

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PRESSURE RATING TABLES - SEAMLESS, PLAIN ENDS - CARBON STEEL PIPE

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX PSI	LBS. PER FT.	MATERIAL CODE NUMBER
Std. (40)	4"	4.500	.237	.207	1507	10.79	1-548-67-0272
XH (80)			.337	.295	2390	14.99	1-548-67-0273
160			.531	.465	4181	22.51	1-548-67-0275
XXH			.674	.590	5575	27.54	1-548-67-0276
Std. (40)	6"	6.625	.280	.245	1266	18.98	1-548-67-0288
XH (80)			.432	.378	2165	28.58	1-548-67-0289
160			.718	.628	3939	45.30	1-548-67-0291
XXH			.864	.756	4892	53.17	1-548-67-0292
Std. (40)	8"	8.625	.322	.282	1154	28.5	1-548-67-0298
60			.406	.355	1528	35.6	1-548-67-0299
XH (80)			.500	.437	1954	43.4	1-548-67-0300
XXH			.875	.765	3729	72.4	1-548-67-0304
160			.906	.792	3880	74.7	1-548-67-0305
20	10"	10.75	.250	.218	664	28.0	1-548-67-0309
30			.307	.268	865	34.2	1-548-67-0311
Std. (40)			.365	.319	1072	40.5	1-548-67-0312
XH (60)			.500	.437	1556	54.7	1-548-67-0313
80			.593	.518	1894	64.3	1-548-67-0314
160			1.125	.985	3926	115.7	1-548-67-0318
20	12"	12.75	.250	.218	559	33.4	1-548-67-0322
30			.330	.288	795	43.8	1-548-67-0323
Std.			.375	.328	932	49.6	1-548-67-0324
40			.406	.355	1024	53.5	1-548-67-0325
XH			.500	.437	1306	65.4	1-548-67-0326
80			.687	.601	1880	88.5	1-548-67-0328
160			1.312	1.148	3885	160.3	1-548-67-0332
10	14"	14.000	.250	.218	509	36.7	1-548-67-0336
20			.312	.273	678	45.7	1-548-67-0337
Std. (30)			.375	.328	849	54.6	1-548-67-0338
40			.438	.383	1018	63.4	1-548-67-0339
XH			.500	.437	1187	72.1	1-548-67-0340
60			.593	.519	1445	85.0	1-548-67-0341
80			.750	.656	1883	106.1	1-548-67-0342
100			.937	.820	2416	130.8	1-548-67-0343
120			1.093	.956	2866	150.8	1-548-67-0344
140			1.250	1.094	3330	170.2	1-548-67-0345
160			1.406	1.230	3796	189.1	1-548-67-0346

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PRESSURE RATING TABLES - SEAMLESS, PLAIN ENDS - CARBON STEEL PIPE

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX. PSI	LBS. PER FT.	MATERIAL CODE NUMBER
10	16"	16.000	.250	.218	445	42.0	1-548-67-0350
20			.312	.273	593	52	1-548-67-0351
Std. (30)			.375	.328	741	63	1-548-67-0352
XH (40)			.500	.437	1036	83	1-548-67-0353
60			.656	.574	1412	108	1-548-67-0354
80			.843	.738	1870	137	1-548-67-0355
100			1.031	.902	2236	165	1-548-67-0356
120			1.218	1.066	2809	192	1-548-67-0357
140			1.438	1.258	3374	224	1-548-67-0358
160			1.593	1.394	3782	245	1-548-67-0359
10	18"	18.000	.250	.218	395	47.0	1-548-67-0363
20			.312	.273	526	59	1-548-67-0364
Std.			.375	.328	658	71	1-548-67-0365
30			.438	.383	788	82	1-548-67-0366
XH			.500	.437	919	94	1-548-67-0367
40			.562	.492	1052	105	1-548-67-0368
60			.750	.656	1453	138	1-548-67-0369
80			.937	.820	1860	171	1-548-67-0370
100			1.156	1.012	2345	208	1-548-67-0371
120			1.375	1.203	2835	244	1-548-67-0372
140			1.562	1.367	3264	274	1-548-67-0373
160			1.781	1.558	3771	309	1-548-67-0374
10	20"	20.000	.250	.218	355	53.0	1-548-67-0378
Std. (20)			.375	.328	591	79	1-548-67-0379
XH (30)			.500	.437	825	104	1-548-67-0380
40			.593	.519	1003	123	1-548-67-0381
60			.812	.710	1423	166	1-548-67-0382
80			1.031	.902	1852	209	1-548-67-0383
100			1.281	1.121	2349	256	1-548-67-0384
120			1.500	1.313	2793	296	1-548-67-0385
140			1.750	1.531	3306	341	1-548-67-0386
160			1.968	1.722	3763	379	1-548-67-0387
10	24"	24.000	.250	.218	296	63.0	1-548-67-0392
Std. (20)			.375	.328	491	95	1-548-67-0393
XH			.500	.437	686	126	1-548-67-0394
30			.562	.492	785	141	1-548-67-0395
40			.687	.601	982	171	1-548-67-0396
60			.968	.847	1443	231	1-548-67-0398
90			1.218	1.066	1840	296	1-548-67-0399
100			1.531	1.339	2357	367	1-548-67-0400
120			1.812	1.585	2831	429	1-548-67-0401
140			2.062	1.804	3260	483	1-548-67-0402
160			2.343	2.050	3750	542	1-548-67-0403

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PRESSURE RATING TABLES - BUTTWELD, PLAIN ENDS - CARBON STEEL PIPE

7. PRESSURE RATING TABLES

WEIGHT OF SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX. PSI	LBS. PER FT.	MATERIAL CODE NUMBER
Std. (40)	1/8"	.405	.068	.059	430	.25	1-546-67-0001
XH (80)			.095	.083	1575	.32	1-546-67-0014
Std. (40)	1/4"	.540	.088	.077	937	.43	1-546-67-0002
XH (80)			.119	.104	1961	.54	1-546-67-0015
Std. (40)	3/8"	.675	.091	.079	819	.57	1-546-67-0003
XH (80)			.106	.110	1729	.74	1-546-67-0016
Std. (40)	1/2"	.840	.109	.095	1061	.85	1-546-67-0004
XH (80)			.147	.128	1821	1.09	1-546-67-0017
XXH			.294	.257	5533	1.72	1-546-67-0036
Std. (40)	3/4"	1.050	.113	.099	870	1.13	1-546-67-0005
XH (80)			.154	.134	1553	1.47	1-546-67-0018
XXH			.308	.269	4518	2.44	1-546-67-0037
Std. (40)	1"	1.315	.133	.116	946	1.68	1-546-67-0006
XH (80)			.179	.156	1560	2.17	1-546-67-0019
XXH			.358	.313	4290	3.66	1-546-67-0038
Std. (40)	1 1/2"	1.900	.145	.127	752	2.72	1-546-67-0008
XH (80)			.200	.175	1250	3.63	1-546-67-0021
XXH			.400	.350	3253	6.41	1-546-67-0040
Std. (40)	2"	2.375	.154	.134	661	3.65	1-546-67-0009
XH (80)			.218	.190	1119	5.02	1-546-67-0022
160			.343	.300	2070	7.45	1-546-67-0032
XXH			.436	.381	2827	9.03	1-546-67-0041
Std. (40)	2 1/2"	2.875	.203	.177	828	5.79	1-546-67-0010
XH (80)			.276	.242	1266	7.66	1-546-67-0023
160			.375	.328	1887	10.01	1-546-67-0033
XXH			.552	.483	3082	13.70	1-546-67-0042
Std. (40)	3"	3.500	.216	.189	738	7.58	1-546-67-0011
XH (80)			.300	.262	1148	10.25	1-546-67-0024
160			.438	.383	1854	14.30	1-546-67-0034
XXH			.600	.525	2740	18.58	1-546-67-0043
Std. (40)	4"	4.500	.237	.207	648	10.79	1-546-67-0013
XH (80)			.337	.29	1024	14.99	1-546-67-0026
160			.531	.46	1790	22.51	1-546-67-0035
XXH			.674	.59	2388	27.54	1-546-67-0044

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PRESSURE RATING TABLES - SEAMLESS, THREADED ENDS - CARBON STEEL PIPE

8. PRESSURE RATING TABLES

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX PSI	MATERIAL CODE NUMBER
XH (80)	1/8"	.405	.095	.083	3660	1-548-67-0202
XH (80)	1/4"	.540	.119	.104	4565	1-548-67-0206
XH (80)	3/8"	.675	.126	.110	4019	1-548-67-0210
Std. (40)	1/2"	.840	.109	.095	1971	1-548-67-0214
XH (80)			.147	.128	3807	1-548-67-0215
160			.187	.164	5957	1-548-67-0217
XXH			.294	.257	12352	1-548-67-0216
Std. (40)	3/4"	1.050	.113	.099	1735	1-548-67-0220
XH (80)			.154	.134	3271	1-548-67-0221
160			.218	.191	5969	1-548-67-0223
XXH			.308	.269	10113	1-548-67-0222
Std. (40)	1"	1.315	.133	.116	1512	1-548-67-0226
XH (80)			.179	.156	2898	1-548-67-0227
160			.250	.218	5194	1-548-67-0229
XXH			.358	.313	9107	1-548-67-0228
Std. (40)	1 1/2"	1.900	.145	.127	1290	1-548-67-0238
XH (80)			.200	.175	2428	1-548-67-0239
160			.281	.246	4201	1-548-67-0241
XXH			.400	.350	7016	1-548-67-0240
Std. (40)	2"	2.375	.154	.134	1156	1-548-67-0244
XH (80)			.218	.190	2211	1-548-67-0245
160			.343	.300	4408	1-548-67-0246
XXH			.436	.381	6143	1-548-67-0247

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GENERAL SERVICE -20°F TO +100°F 275 PSIG MAX OWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/8" thru 3/8"	XH SMLS, Threaded Ends	ASTM A53 Gr B
1/2" thru 2"	Std. SMLS, Threaded Ends	ASTM A53 Gr B
4" and smaller	Std. Buttweld, Plain Ends	ASTM A53
6"	Std. SMLS, Plain Ends	ASTM A53 Gr B
8" thru 12"	Sch. 20 SMLS, Plain Ends	ASTM A53 Gr B
14" thru 24"	Sch. 10 SMLS, Plain Ends	ASTM A53 Gr B
FITTINGS		
2" and smaller	2000# Forged Steel, Threaded Ends (See Note 4)	ASTM A105 Gr 2
2" and smaller	Sch. 40 Forged Steel, Socket Weld Ends	ASTM A105 Gr 2 ASA B16.11
2 1/2" thru 6"	Std. Wt. Wrought Steel, Buttweld Ends	ASTM A234 WPB ASA B16.9
8" thru 12"	Sch. 20 Wrought Steel, Buttweld Ends	ASTM A234 WPB ASA B16.9
14" thru 24"	Sch. 10 Wrought Steel, Buttweld Ends	ASTM A234 WPB ASA B16.9
UNIONS		
2" and smaller	2000# Forged Steel, Ground Joint, Steel-to-steel Seats, Threaded Ends (See Note 4)	ASTM A105 Gr 2
2" and smaller	Sch. 40 Forged Steel, Ground Joint, Steel-to-steel Seats, Socket Weld Ends	ASTM A105 Gr 2 ASA B16.11
FLANGES		
2 1/2" thru 24"	150# Forged Steel, Raised Face, Slip-On	ASTM A181 Gr 1 ASA B16.5
2 1/2" thru 24"	150# Forged Steel, Raised Face Welding Neck	ASTM A181 Gr 1 ASA B16.5

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Date Oct., 1966

APCI DOCUMENT NO. 22000462

GENERAL SERVICE -20°F TO +100°F 275 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
BOLTING		
All sizes	Studs, Alloy Steel, Full Thd. Nuts, Carbon Steel, Hex	ASTM A193 B7 ASTM A194 2H APCI 579.2.2
GASKETS		
All sizes	Ring, Compressed Asbestos 1/16" thick	ASA B16.21 APCI 579.2.3
VALVES		
GATE		
2" and smaller	600# Forged Steel, Threaded Ends	V-63A
2" and smaller	600# Forged Steel, Socket Weld Ends	V-63B
2 1/2" thru 24"	150# Cast Steel, Buttweld Ends	V-121C
2 1/2" thru 24"	150# Cast Steel, Raised Face, Flanged Ends	V-121G
GLOBE		
2" and smaller	600# Forged Steel, Threaded Ends	V-561A
2" and smaller	600# Forged Steel, Socket Weld Ends	V-561B
2 1/2" thru 12"	150# Cast Steel, Buttweld Ends	V-621C
2 1/2" thru 12"	150# Cast Steel, Raised Face, Flanged Ends	V-621G

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GENERAL SERVICE -20°F TO +100°F 275 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
CHECK		
2" and smaller	600# Forged Steel, Lift, Threaded Ends	V-1561A
2" and smaller	600# Forged Steel, Lift, Socket Weld Ends	V-1561B
2 1/2" thru 18"	150# Cast Steel, Buttweld Ends	V-1621C
2 1/2" thru 18"	150# Cast Steel, Raised Face Flanged Ends	V-1621G
ANGLE		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-1061A
3/4" and smaller	600# Forged Steel, Socket Weld Ends	V-1061B
1" thru 2"	600# Forged Steel, Socket Weld Ends	V-1082B
GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	400# CWG Bronze, Threaded Ends	V-2011A

NOTE: 1. Bills of material must specify bore, for buttwelded valves and welding neck flanges.

2. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 4". For detail bend radius data see Design Engineering Standard 578.10.1.1

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GENERAL SERVICE -20°F TO +100°F 275 PSIG MAX CWG CARBON STEEL

NOTES: (Cont'd)

3. This standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	255	350°F	195
200°F	240	400°F	180
250°F	225	450°F	165
300°F	210		

4. Socket weld fittings shall be used wherever possible. The use of screwed end fittings and unions shall be kept to a minimum.

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GENERAL SERVICE -20°F TO +100°F 720 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/8" thru 3/8"	XH Seamless, Threaded Ends	ASTM A53 Gr B
1/2" thru 2"	Std. Seamless, Threaded Ends	ASTM A53 Gr B
16" and smaller	Std. Seamless, Plain Ends	ASTM A53 Gr B
FITTINGS		
2" and smaller	2000# Forged Steel, Threaded Ends	ASTM A105 Gr 2
2" and smaller	Sch. 40 Forged Steel, Socket Weld Ends	ASTM A105 Gr 2 ASA B16.11
2 1/2" thru 16"	Std. Wt. Wrought Steel Buttweld Ends	ASTM A234 WPB ASA B16.9
UNIONS		
2" and smaller	2000# Forged Steel, Ground Joint, Steel-to-Steel Seats, Threaded Ends	ASTM A105 Gr 2
2" and smaller	Sch. 40 Forged Steel, Ground Joint, Steel-to-Steel Seats, Socket Weld Ends	ASTM A105 Gr 2 ASA B16.11
FLANGES		
2 1/2" thru 16"	300# Forged Steel, Raised Face, Slip-On	ASTM A181 Gr 1 ASA B16.5
2 1/2" thru 16"	300# Forged Steel, Raised Face, Welding Neck	ASTM A181 Gr 1 ASA B16.5
BOLTING		
All sizes	Studs, Alloy Steel, Full Thd. Nuts, Carbon Steel, Hex	ASTM A193 B7 ASTM A194 2H APCI 579.2.2

APCI DOCUMENT NO 92000/Z0

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DESIGN ENGINEERING STANDARD

GENERAL SERVICE -20°F TO +100°F 720 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
GASKETS		
All sizes	Ring, Compressed Asbestos 1/16" thick	ASA B16.21 APCI 579.2.3
VALVES		
GATE		
2" and smaller	600# Forged Steel, Threaded Ends	V-63A
2" and smaller	600# Forged Steel, Socket Weld Ends	V-63B
2 1/2" thru 16"	300# Cast Steel, Buttweld Ends	V-131C
2 1/2" thru 16"	300# Cast Steel, Raised Face Flanged Ends	V-131G
GLOBE		
2" and smaller	600# Forged Steel, Threaded Ends	V-561A
2" and smaller	600# Forged Steel, Socket Weld Ends	V-561B
2 1/2" thru 16"	300# Cast Steel, Buttweld Ends	V-631C
2 1/2" thru 16"	300# Cast Steel, Raised Face Flanged Ends	V-631G
CHECK		
2" and smaller	600# Forged Steel, Lift, Threaded Ends	V-1561A
2" and smaller	600# Forged Steel, Lift, Socket Weld Ends	V-1561B

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Date July, 1965

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
CHECK (Cont'd)		
2 1/2" thru 16"	300# Cast Steel, Buttweld Ends	V-1631C
2 1/2" thru 16"	300# Cast Steel, Raised Face Flanged Ends	V-1631G
ANGLE		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-1061A
3/4" and smaller	600# Forged Steel, Socket Weld Ends	V-1061B
1" thru 2"	600# Forged Steel, Socket Weld Ends	V-1082B
GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	3000# CWG Forged Steel, Threaded Ends	V-619A

NOTE: 1. Bills of material must specify bore for buttwelded valves, and bore of welding neck flanges.

2. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 4". For detail bend radius data see Standard 578.10.1.1.

3. This standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	710	350°F	675
200°F	700	400°F	665
250°F	690	450°F	650
300°F	680		

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DESIGN ENGINEERING STANDARDS

570 PIPING CS 14

GENERAL SERVICE -20°F TO +100°F 1440 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/8" thru 3/8"	XH SMLS, Threaded Ends	ASTM A53 Gr B
1/2" thru 3/4"	Std. Seamless, Threaded Ends	ASTM A53 Gr B
4" and smaller	Std. Seamless, Plain Ends	ASTM A53 Gr B
6" thru 10"	XH Seamless, Plain Ends	ASTM A53 Gr B
FITTINGS		
3/4" and smaller	2000# Forged Steel, Threaded Ends	ASTM A105 Gr 2
2" and smaller	Sch. 40 Forged Steel, Socket Weld Ends	ASTM A105 Gr 2 ASA B16.11
2 1/2" thru 4"	Std. Wrought Steel, Buttweld Ends	ASTM A234 WPB ASA B16.9
6" thru 10"	XH Wrought Steel, Buttweld Ends	ASTM A234 WPB ASA B16.9
UNIONS		
1" and smaller	Sch. 40 Forged Steel, Ground Joints, Steel-to-Steel Seats, Socket Weld Ends	ASTM A105 Gr 2 ASA B16.11
FLANGES		
1 1/2" thru 10"	600# Forged Steel, 1/4" Raised Face, Welding Neck	ASTM A105 Gr 2 ASA B16.5
BOLTING		
All sizes	Studs, Alloy Steel, Full Thd. Nuts, Carbon Steel, Hex	ASTM A193 Gr B7 ASTM A194 Gr 2H APCI 579.2.2
GASKETS		
All sizes	Ring, Compressed Asbestos 1/16" thick	ASA B16.21 APCI 579.2.3

APCI DOCUMENT NO. 22000177

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Date July, 1965

DESIGN ENGINEERING STANDARDS

GENERAL SERVICE -20°F TO +100°F 1440 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
VALVES		
GATE		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-63A
1/4" thru 2"	600# Forged Steel, Socket Weld Ends	V-63B
2 1/2" thru 10"	600# Cast Steel, Buttweld Ends	V-141C
2 1/2" thru 10"	600# Cast Steel, Raised Face, Flanged Ends	V-141G
GLOBE		
For Ordinary Service		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-561A
1/4" thru 2"	600# Forged Steel, Socket Weld Ends	V-561B
2 1/2" thru 10"	600# Cast Steel, Buttweld Ends	V-641C
2 1/2" thru 10"	600# Cast Steel, Raised Face, Flanged Ends	V-641G
For compressor blowdown from condensate traps where frequent opening and closing of the valve is encountered.		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-585A
3/4" and smaller	600# Forged Steel, Socket Weld Ends	V-585B

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GENERAL SERVICE -20°F TO +100°F 1440 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
ANGLE		
For Ordinary Service		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-1061A
3/4" and smaller	600# Forged Steel, Socket Weld Ends	V-1061B
1" thru 2"	600# Forged Steel, Socket Weld Ends	V-1082B
For compressor blowdown from condensate traps where frequent opening and closing of the valve is encountered.		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-1083A
3/4" and smaller	600# Forged Steel, Socket Weld Ends	V-1083B
CHECK		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-1561A
1/4" thru 2"	600# Forged Steel, Socket Weld Ends	V-1561B
2 1/2" thru 10"	600# Cast Steel, Buttweld Ends	V-1641C
2 1/2" thru 10"	600# Cast Steel, Raised Face, Flanged Ends	V-1641G
GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	3000# CWG Forged Steel, Threaded Ends	V-619A

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DESIGN ENGINEERING STANDARDS

GENERAL SERVICE -20°F TO +100°F 1440 PSIG MAX CWP CARBON STEEL

NOTE: 1. Bills of material must specify bore for buttwelded valves, and bore of welding neck flanges.

2. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 4". For detail bend radius data see Design Engineering Standard 578.10.1.1.

3. This standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	1410	350°F	1300
200°F	1385	400°F	1275
250°F	1355	450°F	1250
300°F	1330		

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Date July, 196-

GENERAL SERVICE -20°F TO +100°F 2000 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/8" thru 3/4"	XH Seamless, Threaded Ends	ASTM A53 Gr B
6" and smaller	XH Seamless, Plain Ends	ASTM A53 Gr B
FITTINGS		
1/8" thru 3/4"	3000# Forged Steel, Threaded Ends	ASTM A105 Gr 2
2" and smaller	Sch. 80 Forged Steel, Socket Weld Ends	ASTM A105 Gr 2 ASA B16.11
2 1/2" thru 6"	XH Wrought Steel, Buttweld Ends	ASTM A234 WPB ASA B16.9
UNIONS		
1" and smaller	Sch. 80 Forged Steel, Ground Joints, Steel-to-Steel Seats, Socket Weld Ends	ASTM A105 Gr 2 ASA B16.11
FLANGES		
1 1/2" thru 6"	900# Forged Steel, 1/4" Raised Face, Welding Neck	ASTM A105 Gr 2 ASA B16.5
BOLTING		
1 1/2" thru 6"	Studs, Alloy Steel, Full Thd. Nuts, Carbon Steel, Hex	ASTM A193 Gr B7 ASTM A194 Gr 2H APCI 579.2.2
GASKETS		
All sizes	Ring Compressed Asbestos 1/16" thick	ASA B16.21 APCI 579.2.3
VALVES		
GATE		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-63[illegible]

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GENERAL SERVICE -20°F TO +100°F 2000 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
GATE		
2" and smaller	600# Forged Steel, Socket Weld Ends	V-63B
2 1/2" thru 6"	900# Cast Steel, Buttweld Ends	V-151C
2 1/2" thru 6"	900# Cast Steel, Raised Face, Flanged Ends	V-151G
GLOBE		
For Ordinary Service		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-561A
3/4" and smaller	600# Forged Steel, Socket Weld Ends	V-561B
1" thru 2"	600# Forged Steel, Socket Weld Ends	V-584B
2 1/2" thru 6"	900# Cast Steel, Buttweld Ends	V-651C
2 1/2" thru 6"	900# Cast steel, Raised Face, Flanged Ends	V-651G
For compressor blowdown from condensate traps where frequent opening and closing of the valve is encountered.		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-585A
3/4" and smaller	600# Forged Steel, Socket Weld Ends	V-585B

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GENERAL SERVICE -20°F TO +100°F 2000 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
ANGLE		
For Ordinary Service		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-1061A
3/4" and smaller	600# Forged Steel, Socket Weld Ends	V-1061B
1" thru 2"	600# Forged Steel, Socket Weld Ends	V-1082B
For compressor blowdown from condensate traps where frequent opening and closing of the valve is encountered.		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-1083A
3/4" and smaller	600# Forged Steel, Socket Weld Ends	V-1083B
CHECK		
3/4" and smaller	600# Forged Steel, Threaded Ends	V-1561A
2" and smaller	600# Forged Steel, Socket Weld Ends	V-1561B
2 1/2" thru 6"	900# Cast Steel, Buttweld Ends	V-1651C
2 1/2" thru 6"	900# Cast Steel, Raised Face, Flanged Ends	V-1651G
GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	3000# CWG Forged Steel, Threaded Ends	V-619A

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GENERAL SERVICE -20°F TO +100°F 2000 PSIG MAX CWG CARBON STEEL

NOTE: 1. Bills of Material must specify bore for buttwelded valves, and bore of welding neck flanges.

2. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 4". For detail bend radius see Design Engineering Standard 578.10.1.1.

3. This standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	1965	350°F	1810
200°F	1925	400°F	1770
250°F	1885	450°F	1735
300°F	1845		

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DESIGN ENGINEERING STANDARDS

570 PIPING CS 36

GENERAL SERVICE -20°F TO +100°F 3600 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/4" thru 1/2"	XH Seamless, Threaded Ends	ASTM A53 Gr B
1/4" thru 1/2"	XH Seamless, Plain Ends	ASTM A53 Gr B
3/4" thru 6"	Sch. 160 Seamless, Plain Ends	ASTM A53 Gr B
FITTINGS		
1/2" and smaller	6000# Forged Steel, Threaded Ends	ASTM A105 Gr 2
2" and smaller	Sch. 160 Forged Steel, Socket Weld Ends	ASTM A105 Gr 2 ASA B16.11
2 1/2" thru 6"	Sch. 160 Wrought Steel, Buttweld Ends	ASTM A234 WPB ASA B16.9
FLANGES		
All sizes	1500# Forged Steel, RTJ, Welding Neck	ASTM A105 Gr 2 ASA B16.5
BOLTING		
All sizes	Studs, Alloy Steel, Full Thd. Nuts, Carbon Steel, Hex	ASTM A193 Gr B7 ASTM A194 Gr 2H APCI 579.2.2
GASKETS		
All sizes	Ring Joint, Low Carbon Steel, Oval, Max. Brinell 90	ASA B16.20
VALVES		
GATE		
3/4" and smaller	1500# Forged Steel, Socket Weld Ends	V-75B
1" thru 2"	1500# Forged Steel, Socket Weld Ends	V-91B

APCI DOCUMENT NO 99000123

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Date July, 1965

DESIGN ENGINEERING STANDARDS

GENERAL SERVICE -20°F TO +100°F 3600 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
GATE (Cont'd)		
2 1/2" thru 6"	1500# Cast Steel, Buttweld Ends	V-161C
2 1/2" thru 6"	1500# Cast Steel, RTJ Flanged Ends	V-161H
GLOBE		
3/4" and smaller	1500# Forged Steel, Socket Weld Ends	V-593B
1" thru 2"	1500# Forged Steel, Socket Weld Ends	V-601B
2 1/2" thru 6"	1500# Cast Steel, Buttweld Ends	V-661C
2 1/2" thru 6"	1500# Cast Steel, RTJ Flanged Ends	V-661H
ANGLE		
3/4" and smaller	1500# Forged Steel, Socket Weld Ends	V-1064B
1" thru 2"	1500# Forged Steel, Socket Weld Ends	V-1101B
CHECK		
3/4" and smaller	1500# Forged Steel, Piston Socket Weld Ends	V-1581B
1" thru 2"	1500# Forged Steel, Piston, Socket Weld Ends	V-1582B
2 1/2" thru 6"	1500# Cast Steel, Swing, Buttweld Ends	V-1661C
2 1/2" thru 6"	1500# Cast Steel, Swing, RTJ, Flanged Ends	V-1661H

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Date July, 1965

GENERAL SERVICE -20°F TO +100°F 3600 PSIG MAX CWG CARBON STEEL

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	4000# CWG Forged Steel, Threaded Ends	V-618A

NOTE: 1. Bills of material must specify bore for buttwelded valves, also bore of welding neck flanges.

2. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 4". For detail bend radius data see Design Engineering Standard 578.10.1.1.

3. This standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	3535	350°F	3255
200°F	3465	400°F	3185
250°F	3390	450°F	3120
300°F	3320		

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PRESSURE RATING TABLES - PLAIN AND THREADED ENDS - STAINLESS STEEL PIPE

1. PURPOSE

The purpose of this standard is to provide the Maximum Allowable Pressure for stainless steel pipe with plain ends and threaded ends.

2. SCOPE

This standard encompasses stainless steel pipe made according to ASTM specifications A312 TP304.

3. MATERIAL SPECIFICATIONS

The following material specifications apply to the pipe described herein:

A.	MATERIAL DESCRIPTION	IPS SIZE RANGE
(1)	PIPE SMLS STSTL	1/8" thru 12"
(2)	PIPE IGW STSTL	1/8" thru 12"

4. ALLOWABLE STRESS VALUE

The allowable stress values for the material described in this standard are based on the ASA B31.3 American Standard Code for Pressure Piping, Petroleum Refinery Piping, Table 302.3.1A and 302.3.1B.

A.	MATERIAL DESCRIPTION	ALLOWABLE STRESS VALUE
(1)	PIPE SMLS ASTM A312 TP304	18,750 PSI
(2)	PIPE IGW ASTM A312 TP304	15,000 PSI

5. MAXIMUM ALLOWABLE PRESSURE

The maximum allowable pressure for the pipe is based on the following formula from ASA B31.3 1959 American Standard Code for Pressure Piping, Petroleum Refinery Piping, Para. 304.1.2.

A. Formula:

$$P = \frac{2S\,(t_m - C)}{D - 0.8\,(t_m - C)}$$

P = Maximum Allowable Pressure, PSI
S = Maximum Allowable Hoop Stress from 4A
D = O.D. of pipe listed in standard pipe specifications
t_m = Maximum wall thickness as specified by above code
C = 0.0 for plain end pipe
C = Depth of thread or 0.05 whichever is greater.

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Date
May, 1962

APCI DOCUMENT NO. 99-000-24

DESIGN ENGINEERING STANDARDS

570 PIPING

PRESSURE RATING TABLES - SEAMLESS, PLAIN ENDS - STAINLESS STEEL PIPE

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX PSI	LBS. PER FT.	MATERIAL CODE NUMBER
5S	1/8"	.405	.035	.0306	3104	.1383	1-552-69-
10S			.049	.0428	4329	.186	1-552-69-0016
40S			.068	.0595	6072	.245	1-552-69-0034
80S			.095	.0831	9205	.314	1-552-69-0052
5S	1/4"	.540	.049	.0428	3173	.2570	1-552-69-
10S			.065	.0568	4307	.330	1-552-69-0017
40S			.088	.077	6034	.425	1-552-69-0035
80S			.119	.1041	8546	.535	1-552-69-0053
5S	3/8"	.675	.049	.0428	2505	.3276	1-552-69-
10S			.065	.0568	3383	.423	1-552-69-0018
40S			.091	.0796	4883	.568	1-552-69-0036
80S			.126	.1102	7041	.739	1-552-69-0054
5S	1/2"	.840	.065	.0568	2680	.4139	1-552-69-0001
10S			.083	.0726	3483	.671	1-552-69-0019
40S			.109	.0953	4690	.851	1-552-69-0037
80S			.147	.1286	6550	1.088	1-552-69-0055
5S	3/4"	1.050	.065	.0568	2122	.634	1-552-69-0002
10S			.083	.0726	2745	.857	1-552-69-0020
40S			.113	.0988	3820	1.131	1-552-69-0038
80S			.154	.1347	5370	1.474	1-552-69-0056
5S	1"	1.315	.065	.0568	1680	.868	1-552-69-0003
10S			.109	.0953	2887	1.806	1-552-69-0021
40S			.133	.1163	3580	1.679	1-552-69-0039
80S			.179	.1566	4940	2.172	1-552-69-0057
5S	1 1/2"	1.900	.065	.0568	1149	1.274	1-552-69-0005
10S			.109	.0953	1961	2.085	1-552-69-0023
40S			.145	.1268	2650	2.718	1-552-69-0041
80S			.200	.175	3730	3.632	1-552-69-0059
5S	2"	2.375	.065	.0568	915	1.604	1-552-69-0006
10S			.109	.0953	1556	2.638	1-552-69-0024
40S			.154	.1347	2230	3.653	1-552-69-0042
80S			.218	.1907	3220	5.022	1-552-69-0060
5S	2 1/2"	2.875	.083	.0726	967	2.475	1-552-69-0007
10S			.120	.105	1410	3.531	1-552-69-0025
40S			.203	.1776	2440	5.793	1-552-69-0043
80S			.276	.2515	3380	7.662	1-552-69-0061

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Date

May, 1962

PRESSURE RATING TABLES - SEAMLESS, PLAIN END - STAINLESS STEEL PIPE

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX PSI	LBS. PER FT.	MATERIAL CODE NUMBER
5S	3"	3.500	.083	.0726	791	3.029	1-552-69-0008
10S			.120	.105	1153	4.332	1-552-69-0026
40S			.216	.189	2120	7.576	1-552-69-0044
80S			.300	.2625	3000	10.25	1-552-69-0062
5S	4"	4.500	.083	.0726	613	3.915	1-552-69-0010
10S			.120	.105	892	5.613	1-552-69-0028
40S			.237	.2073	1800	10.79	1-552-69-0046
80S			.337	.2948	2600	14.99	1-552-69-0064
5S	6"	6.625	.109	.0953	541	7.585	1-552-69-0012
10S			.134	.1172	673	9.289	1-552-69-0030
40S			.280	.245	1430	18.97	1-552-69-0048
80S			.432	.378	2250	28.58	1-552-69-0066
5S	8"	8.625	.109	.0953	418	9.914	1-552-69-0013
10S			.148	.1295	570	13.40	1-552-69-0031
40S			.322	.2817	1260	28.55	1-552-69-0049
80S			.500	.4375	1990	43.4	1-552-69-0067
5S	10"	10.750	.134	.1172	412	15.19	1-552-69-0014
10S			.165	.1443	510	18.65	1-552-69-0032
40S			.365	.3193	1150	40.80	1-552-69-0050
80S			.500	.4375	1580	54.7	1-552-69-0068
5S	12"	12.750	.165	.1443	429	22.18	1-552-69-0015
10S			.180	.1575	468	24.16	1-552-69-0033
40S			.375	.3281	990	49.56	1-552-69-0051
80S			.500	.4375	1330	65.4	1-552-69-0069

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PRESSURE RATING TABLES - SEAMLESS, THREADED ENDS - STAINLESS STEEL PIPE

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX. PSI	MATERIAL CODE NUMBER
40S	1/8"	.405	.068	.059	847	1-552-69-0034
80S			.095	.983	3268	1-552-69-0052
40S	1/4"	.540	.088	.077	1953	1-552-69-0035
80S			.119	.104	4076	1-552-69-0053
40S	3/8"	.675	.091	.079	1668	1-552-69-0036
80S			.126	.110	3588	1-552-69-0054
40S	1/2"	.840	.109	.095	1760	1-552-69-0037
80S			.147	.128	3399	1-552-69-0055
40S	3/4"	1.050	.113	.099	1549	1-552-69-0038
80S			.154	.134	2921	1-552-69-0056
40S	1"	1.315	.133	.116	1361	1-552-69-0039
80S			.179	.156	2600	1-552-69-0057
40S	1 1/2"	1.900	.145	.127	1161	1-552-69-0041
80S			.200	.175	2177	1-552-69-0059
40S	2"	2.375	.154	.135	1039	1-552-69-0042
80S			.218	.190	1981	1-552-69-0060

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PRESSURE RATING TABLES - IGW PLAIN ENDS - STAINLESS STEEL PIPE

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX PSI	LBS. PER FT.	MATERIAL CODE NUMBER
5S	1/8"	.405	.035	.0306	2412	.1383	1-554-69-
10S			.049	.0428	3463	.186	1-554-69-0016
40S			.068	.0595	4994	.245	1-554-69-0034
80S			.095	.0831	7364	.314	1-554-69-0052
5S	1/4"	.540	.049	.0428	2539	.2570	1-554-69-
10S			.065	.0568	3445	.330	1-554-69-0017
40S			.088	.077	4829	.425	1-554-69-0035
80S			.119	.1041	6838	.535	1-554-69-0053
5S	3/8"	.675	.049	.0428	2004	.3276	1-554-69-
10S			.065	.0568	2707	.423	1-554-69-0018
40S			.091	.0796	3906	.568	1-554-69-0036
80S			.126	.1102	5634	.739	1-554-69-0054
5S	1/2"	.840	.065	.0568	2144	.4139	1-554-69-0001
10S			.083	.0726	2785	.671	1-554-69-0019
40S			.109	.0953	3743	.851	1-554-69-0037
80S			.147	.1286	5234	1.088	1-554-69-0055
5S	3/4"	1.050	.065	.0568	1696	.634	1-554-69-0002
10S			.083	.0726	2196	.857	1-554-69-0020
40S			.113	.0988	3053	1.131	1-554-69-0038
80S			.154	.1347	4289	1.474	1-554-69-0056
5S	1"	1.315	.065	.0568	1342	.868	1-554-69-0003
10S			.109	.0953	2307	1.806	1-554-69-0021
40S			.133	.1163	2855	1.679	1-554-69-0039
80S			.179	.1566	3948	2.172	1-554-69-0057
5S	1 1/2"	1.900	.065	.0568	919	1.274	1-554-69-0005
10S			.109	.0953	1568	2.085	1-554-69-0023
40S			.145	.1268	2115	2.718	1-554-69-0041
80S			.200	.175	2982	3.632	1-554-69-0059
5S	2"	2.375	.065	.0568	731	1.604	1-554-69-0006
10S			.109	.0953	1244	2.638	1-554-69-0024
40S			.154	.1347	1782	3.653	1-554-69-0042
80S			.218	.1907	2574	5.022	1-554-69-0060
5S	2 1/2"	2.875	.083	.0726	773	2.475	1-554-69-0007
10S			.120	.105	1129	3.531	1-554-69-0025
40S			.203	.1776	1950	5.793	1-554-69-0043
80S			.276	.2515	2822	7.662	1-554-69-0061

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Date
May, 1962

DESIGN ENGINEERING STANDARDS
570 PIPING

PRESSURE RATING TABLES - IGW PLAIN ENDS - STAINLESS STEEL PIPE

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX PSI	LBS. PER FT.	MATERIAL CODE NUMBER
5S	3"	3.500	.083	.0726	633	3.029	1-554-69-0008
10S			.120	.105	922	4.332	1-554-69-0026
40S			.216	.189	1693	7.576	1-554-69-0044
80S			.300	.2625	2393	10.25	1-554-69-0062
5S	4"	4.500	.083	.0726	490	3.915	1-554-69-0010
10S			.120	.105	713	5.613	1-554-69-0028
40S			.237	.2073	1435	10.79	1-554-69-0046
80S			.337	.2948	2074	14.99	1-554-69-0064
5S	6"	6.625	.109	.0953	437	7.585	1-554-69-0012
10S			.134	.1172	538	9.289	1-554-69-0030
40S			.280	.245	1143	18.97	1-554-69-0048
80S			.432	.378	1794	28.58	1-554-69-0066
5S	8"	8.625	.109	.0953	334	9.914	1-554-69-0013
10S			.148	.1295	456	13.40	1-554-69-0031
40S			.322	.2817	1006	28.55	1-554-69-0049
80S			.500	.4375	1586	43.4	1-554-69-0067
5S	10"	10.750	.134	.1172	330	15.19	1-554-69-0014
10S			.165	.1443	407	18.65	1-554-69-0032
40S			.365	.3197	913	40.80	1-554-69-0050
80S			.500	.4375	1262	54.7	1-554-69-0068
5S	12"	12.750	.165	.1443	342	22.18	1-554-69-0015
10S			.180	.1575	374	24.16	1-554-69-0033
40S			.375	.3281	788	49.56	1-554-69-0051
80S			.500	.4375	1059	65.4	1-554-69-0069

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Date
May, 1962

PRESSURE RATING TABLES - IGW THREADED ENDS - STAINLESS STEEL PIPE

WEIGHT OR SCH.	NOM. SIZE	O.D.	NOM. WALL (t)	MIN. WALL (t_m)	MAX PSI	MATERIAL CODE NUMBER
40S	1/8"	.405	.068	.059	680	1-554-69-0034
80S			.095	.983	2615	1-554-69-0052
40S	1/4"	.540	.088	.077	1562	1-554-69-0035
80S			.119	.104	3261	1-554-69-0053
40S	3/8"	.675	.091	.079	1334	1-554-69-0036
80S			.126	.110	2871	1-554-69-0054
40S	1/2"	.840	.109	.095	1407	1-554-69-0037
80S			.147	.128	2719	1-554-69-0055
40S	3/4"	1.050	.113	.099	1239	1-554-69-0038
80S			.154	.134	2336	1-554-69-0056
40S	1"	1.315	.133	.116	1088	1-554-69-0039
80S			.179	.156	2080	1-554-69-0057
40S	1 1/2"	1.900	.145	.127	929	1-554-69-0041
80S			.200	.175	1741	1-554-69-0059
40S	2"	2.375	.154	.135	832	1-554-69-0042
80S			.218	.190	1584	1-554-69-0060

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Date
May, 1969

COLD BOX SERVICE +100°F & BELOW 275 PSIG MAX OWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/8" thru 3/8"	Sch. 80S, IG Welded, Threaded Ends (Instrument Connections Only - See Note 4)	ASTM A312 Tp 304
1/2" thru 1"	Sch. 40S, IG Welded, Threaded Ends (Instrument Connections Only - See Note 4)	ASTM A312 Tp 304
2" and smaller	Sch. 10S, IG Welded, Plain Ends	ASTM A312 Tp 304
2 1/2" thru 12"	Sch. 5S, IG Welded, Plain Ends	ASTM A312 Tp 304
FITTINGS (See Note 5)		
3/4" and smaller	2000# Forged, Screwed Ends, Warm Zone Only (Instrument Connections Only - See Note 4)	ASTM A182 Gr F304
2" and smaller	Sch. 10S Wrought, Long Tangent Type with Belled Ends	ASTM A403 WP304L
2 1/2" thru 12"	Sch. 5S, Wrought, Buttweld Ends	ASTM A403 WP304L
UNIONS		
3/4" and smaller	2000#, Forged, Ground Joint, Screwed Ends, Warm Zone Only (Instrument Connections Only - See Note 4)	ASTM A182 Gr F304
1 1/2" and smaller	Sch. 40S, Forged, Ground Joint, Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
FLANGES		
2" thru 12"	150# Forged, 1/16" Raised Face, Welding Neck, Bore for Schedule of Pipe	ASTM A182 Gr F304 ASA B16.5

APCI DOCUMENT NO 99000/75

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Date Nov. 1967

COLD BOX SERVICE +100°F & BELOW 275 PSIG MAX OWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
BOLTING		
All Sizes	Studs, Full Thd., STSTL, Tp 304 Nuts, Hex, STSTL, Tp 321 (Alternate STSTL Tp 316)	ASTM A320 Sym B8 ASTM A194 Sym 8T APCI 579.2.2
GASKETS		
All Sizes	Ring, Compressed Asbestos 1/16" thick	ASA B16.21 APCI 579.2.3
VALVES		
GATE		
1" and smaller	150# Cast STSTL, Type 304, Screwed, Warm Zone Only	V-243A
2" and smaller	150# Cast STSTL, Type 304, Socket Weld Ends	V-243B
2" and smaller	Same - Extended Bonnet	EBV-243B
2 1/2" thru 12"	150# Cast STSTL, Type 304, Buttweld Ends	V-243C
2 1/2" thru 12"	Same - Extended Bonnet	EBV-243C
GLOBE		
1" and smaller	150# Cast STSTL, Type 304, Screwed, Warm Zone Only	V-743A
2" and smaller	150# Cast STSTL, Type 304, Socket Weld Ends	V-743B
2" and smaller	Same - Extended Bonnet	EBV-743B
2 1/2" thru 12"	150# Cast STSTL, Type 304, Buttweld Ends	V-743C
2 1/2" thru 12"	Same - Extended Bonnet	EBV-743C

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COLD BOX SERVICE +100°F & BELOW 275 PSIG MAX CWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
ANGLE		
1" and smaller	150# Cast STSTL, Type 304, Screwed, Warm Zone Only	V-1243A
2" and smaller	150# Cast STSTL, Type 304, Socket Weld Ends	V-1243B
2" and smaller	Same - Extended Bonnet	EBV-1243B
2 1/2" thru 12"	150# Cast STSTL, Type 304, Buttweld Ends	V-1243C
2 1/2" thru 12"	Same - Extended Bonnet	EBV-1243C
CHECK		
1" and smaller	150# Cast STSTL, Type 304, Swing, Screwed, Warm Zone Only	V-1742A
2" and smaller	150# Cast STSTL, Type 304, Swing, Socket Weld Ends	V-1742B
2 1/2" thru 12"	150# Cast STSTL, Type 304, Swing, Buttweld Ends	V-1742C
GLOBE (FOR PRESSURE GAUGE & INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	400# CWG Bronze, Needle Type, Screwed Ends, (Warm Zone Only)	V-2011A

NOTE: 1. Bills of Material must specify bore for buttweld end valves and welding neck flanges.

2. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 4". For detail bend radius data see Design Engineering Standard 578.30.1.1.

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COLD BOX SERVICE +100°F & BELOW 275 PSIG MAX OWG STAINLESS STEEL PIPE

NOTES: (Cont'd)

3. This standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	255	350°F	195
200°F	240	400°F	180
250°F	225	450°F	165
300°F	210		

4. Threaded pipe and fittings are restricted to use at instruments, pressure gauges, pressure taps, and safety valve connections only.

5. Branch connections may be used where economically justifiable. Consult with piping squad leader and stress analyst prior to their use.

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COLD BOX SERVICE +100°F & BELOW 615 PSIG MAX CWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/8" thru 3/8"	Sch. 80S, IG Welded, Threaded Ends (Instrument Connections Only - See Note 4)	ASTM A312 Tp 304
1/2" and 3/4"	Sch. 40S, IG Welded, Threaded Ends (Instrument Connections Only - See Note 4)	ASTM A312 Tp 304
4" and smaller	Sch. 10S, IG Welded, Plain Ends	ASTM A312 Tp 304
6" thru 12"	Sch. 40S, IG Welded, Plain Ends	ASTM A312 Tp 304
FITTINGS (See Note 5)		
3/4" and smaller	2000#, Forged, Screwed Ends, Warm Zone Only (Instrument Connections Only - See Note 4)	ASTM A182 Gr F304
2" and smaller	Sch. 10S Wrought, Long Tangent Type with Belled Ends (2" Belled Tees are not permitted)	ASTM A403 WP304L
2" (TEES)	Sch. 40S, Forged, Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
2 1/2" thru 4"	Sch. 10S, Wrought, Buttweld Ends	ASTM A403 WP304
6" thru 12"	Sch. 40S, Wrought, Buttweld Ends	ASTM A403 WP304
UNIONS		
3/4" and smaller	2000#, Forged, Ground Joint, Screwed, Warm Zone Only (Instrument Connections Only - See Note 4)	ASTM A182 Gr F304
1 1/2" and smaller	Sch. 40S, Forged, Ground Joint, Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11

APCI DOCUMENT NO 88000126

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DESIGN ENGINEERING STANDARDS

570 PIPINC

COLD BOX SERVICE +100°F & BELOW 615 PSIG MAX CWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
FLANGES		
2" thru 12"	300# Forged, 1/16" Raised Face, Welding Neck, Bore for Sch. of Pipe	ASTM A182 Gr F304 ASA B16.5
BOLTING		
All Sizes	Studs, Full Thd., STSTL, Tp 304 Nuts, Hex, STSTL, Tp 321 (Alternate STSTL Tp 316)	ASTM A320 Sym B8 ASTM A194 Sym 8T APCI 579.2.2
GASKETS	Ring, Compressed Asbestos, 1/16" thick	ASA B16.21 APCI 579.2.3
VALVES		
GATE		
3/4" and smaller	300# Cast STSTL, Type 304, Screwed, Warm Zone Only	V-253A
2" and smaller	300# Cast STSTL, Type 304, Socket Weld Ends	V-253B
2" and smaller	Same - Extended Bonnet	EBV-253B
2 1/2" thru 12"	300# Cast STSTL, Type 304, Buttweld Ends	V-253C
2 1/2" thru 12"	Same - Extended Bonnet	EBV-253C
GLOBE		
3/4" and smaller	300# Cast STSTL, Type 304, Screwed, Wa? Zone Only	V-751A
2" and smaller	300# Cast STSTL, Type 304, Socket Weld Ends	V-751B
2" and smaller	Same - Extended Bonnet	EBV-751B
2 1/2" thru 8"	300# Cast STSTL, Type 304, Buttweld Ends	V-751C
2 1/2" thru 8"	Same - Extended Bonnet	EBV-751C

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Date Nov., 1967

COLD BOX SERVICE +100°F & BELOW 615 PSIG MAX OWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
ANGLE		
3/4" and smaller	300# Cast STSTL, Type 304, Screwed Ends, Warm Zone Only	V-1251A
2" and smaller	300# Cast STSTL, Type 304, Socket Weld Ends	V-1251B
2" and smaller	Same - Extended Bonnet	EBV-1251B
2 1/2" thru 8"	300# Cast STSTL, Type 304, Buttweld Ends	V-1251C
2 1/2" thru 8"	Same - Extended Bonnet	EBV-1251C
CHECK		
3/4" and smaller	300# Cast STSTL, Type 304, Swing, Screwed, Warm Zone Only	V-1751A
2" and smaller	300# Cast STSTL, Type 304, Swing, Socket Weld Ends	V-1751B
2 1/2" thru 12"	300# Cast STSTL, Type 304, Swing, Buttweld Ends	V-1751C
GLOBE (FOR PRESSURE GAUGE & INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	3000# OWG, Forged STSTL, Type 304, Screwed Ends, (Warm Zone Only)	V-719A

NOTE: 1. Bills of Material must specify bore for buttweld end valves and welding neck flanges.

2. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 4". For detail bend radius data see Design Engineering Standard 578.30.1.1.

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COLD BOX SERVICE +100°F & BELOW 615 PSIG MAX OWG STAINLESS STEEL PIPE

NOTE: (Cont'd)

3. This standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	585	350°F	470
200°F	550	400°F	450
250°F	520	450°F	430
300°F	495		

4. Threaded pipe and fittings are restricted to use at instruments, pressure gauges, pressure taps, and safety valve connections only.

5. In sizes 6" thru 12" branch connections may be used where economically justifiable. Consult with piping squad leader and stress analyst prior to their use.

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COLD BOX SERVICE +100°F & BELOW 1235 PSIG MAX CWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/8" thru 3/8"	Sch. 80S, IG Welded, Threaded Ends	ASTM A312 Tp 304
1/2" and 3/4"	Sch. 40S, IG Welded, Threaded Ends	ASTM A312 Tp 304
2" and Smaller	Sch. 10S, IG Welded, Plain Ends	ASTM A312 Tp 304
2 1/2" thru 6"	Sch. 40S, IG Welded, Plain Ends	ASTM A312 Tp 304
FITTINGS		
3/4" and Smaller	2000# Forged, Screwed Ends, Warm Zone Only	ASTM A182 Gr F304
2" and Smaller	Sch. 40S, Forged, Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
2 1/2" thru 6"	Sch. 40S, Wrought, Buttweld Ends	ASTM A403 WP304 ASA B16.9
UNIONS		
1 1/2" and Smaller	Sch. 40S, Forged, Ground Joint Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
FLANGES		
2" and Larger	600# Forged, 1/4" Raised Face, Welding Neck, Bore inside to match Schedule of Pipe	ASTM A182 Gr F304 ASA B16.5
BOLTING		
All Sizes	Studs, Full Thd., STSTL, Tp 304 Nuts, Hex, STSTL, Tp 321 (Alternate STSTL Tp 316)	ASTM A320 Sym B8 ASTM A194 Sym 8T
GASKETS		
All Sizes	Ring, Compressed Asbestos, 1/16" thick	ASA B16.21

APCI DOCUMENT NO. 22000122

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Date Jan. 1944

COLD BOX SERVICE +100°F & BELOW 1235 PSIG MAX OWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
VALVES		
GATE		
2" and Smaller	600# Cast STSTL, Type 304, Socket Weld Ends	V-261B
2" and Smaller	Same - Extended Bonnet	EBV-261B
2 1/2" thru 6"	600# Cast STSTL, Type 304, Buttweld Ends	V-261C
2 1/2" thru 6"	Same - Extended Bonnet	EBV-261C
GLOBE		
2" and Smaller	600# Cast STSTL, Type 304, Socket Weld Ends	V-761B
2" and Smaller	Same - Extended Bonnet	EBV-761B
2 1/2" thru 6"	600# Cast STSTL, Type 304, Buttweld Ends	V-761C
2 1/2" thru 6"	Same - Extended Bonnet	EBV-761C
ANGLE		
2" and Smaller	600# Cast STSTL, Type 304, Socket Weld Ends	V-1261B
2" and Smaller	Same - Extended Bonnet	EBV-1261B
2 1/2" thru 6"	600# Cast STSTL, Type 304, Buttweld Ends	V-1261C
2 1/2" thru 6"	Same - Extended Bonnet	EBV-1261C
CHECK		
2" and Smaller	600# Cast STSTL, Type 304, Socket Weld Ends, Swing	V-1761B
2 1/2" thru 6"	600# Cast STSTL, Type 304, Swing, Buttweld Ends	V-1761C

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COLD BOX SERVICE +100°F & BELOW 1235 PSIG MAX CWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	3000# CWG Forged STSTL, Type 304 Screwed Ends, (Warm Zone Only)	V-719A

NOTE: 1. Bills of Material must specify bore for buttweld end valve and welding neck flanges.

2. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 4". For detail bend radius data see Design Engineering Standard 578.30.1.1.

3. This standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	1160	350°F	940
200°F	1095	400°F	900
250°F	1040	450°F	860
300°F	985		

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COLD BOX SERVICE +100°F & BELOW 1715 PSIG MAX OWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
3/4" and Smaller	Sch. 80S, IG Welded, Threaded Ends	ASTM A312 TP 304
1" and Smaller	Sch. 10S, IG Welded, Plain Ends	ASTM A312 TP 304
1 1/2" thru 2 1/2"	Sch. 40S IG Welded, Plain Ends	ASTM A312 TP 304
3" and 4"	Sch. 40S, Seamless, Plain Ends	ASTM A312 TP 304
6"	Sch. 80S, IG Welded, Plain Ends	ASTM A312 TP 304
FITTINGS		
3/4" and Smaller	2000# Forged, Screwed Ends Warm Zone Only	ASTM A182 Gr F304
2" and Smaller	Sch. 40S, Forged, Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
2 1/2" thru 4"	Sch. 40S, Wrought, Buttweld Ends	ASTM A403 WP304 ASA B16.9
6"	Sch. 80S, Wrought, Buttweld Ends	ASTM A403 WP304 ASA B16.9
UNIONS		
1 1/2" and Smaller	Sch. 40S, Forged, Ground Joint Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
FLANGES		
2" and Larger	900# Forged, 1/4" Raised Face, Welding Neck, Bore inside to match Schedule of Pipe	ASTM A182 Gr F304 ASA B16.5
BOLTING		
All Sizes	Studs, Full Thd., STSTL, Tp 304 Nuts, Hex, STSTL, Tp 321 (Alternate STSTL Tp 316)	ASTM A320 Sym B8 ASTM A194 Sym 8T

APCI DOCUMENT NO. 9000-78

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COLD BOX SERVICE +100°F & BELOW 1715 PSIG MAX CWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
GASKETS		
All Sizes	Ring, Compressed Asbestos, 1/16" thick	ASA B16.21
VALVES		
GATE		
2" and Smaller	1715# CWG Forged STSTL, Type 304, Socket Weld Ends	V-183B
2" and Smaller	Same - Extended Bonnet	EBV-183B
3" thru 6"	900# Cast STSTL, Type 304, Buttweld Ends	V-271C
3" thru 6"	Same - Extended Bonnet	EBV-271C
GLOBE		
1" and Smaller	1715# CWG Forged STSTL, Type 304, Socket Weld Ends	V-682B
1" and Smaller	Same - Extended Bonnet	EBV-682B
1 1/2" and 2"	1715# CWG Forged STSTL, Type 304, Socket Weld Ends	V-683B
1 1/2" and 2"	Same - Extended Bonnet	EBV-683B
2 1/2" thru 6"	900# Cast STSTL, Type 304, Buttweld Ends	V-771C
2 1/2" thru 6"	Same - Extended Bonnet	EBV-771C
ANGLE		
1" and Smaller	1715# CWG Forged STSTL, Type 304, Socket Weld Ends	V-1183B
1" and Smaller	Same - Extended Bonnet	EBV-1183B

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COLD BOX SERVICE +100°F & BELOW 1715 PSIG MAX CWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
ANGLE (Cont'd)		
1 1/2" and 2"	1715# CWG Forged STSTL, Type 304, Socket Weld Ends	V-1184C
1 1/2" and 2"	Same - Extended Bonnet	EBV-1184B
2 1/2" thru 6"	900# Cast STSTL, Type 304, Buttweld Ends	V-1271C
2 1/2" thru 6"	Same - Extended Bonnet	EBV-1271C
CHECK		
2 1/2" and Smaller	1715# CWG Cast STSTL, Type 304, Piston, Socket Weld Ends	V-1682B
3" and Larger	900# Cast STSTL, Type 304, Swing, Buttweld Ends	V-1771C
GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	3000# CWG Forged STSTL, Type 304, Screwed Ends (Warm Zone Only)	V-719A

NOTE: 1. Bills of Material must specify bore for buttweld end valves and welding neck flanges.

2. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 4". For detail bend radius data see Design Engineering Standard 578.30.1.1.

3. This standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	1610	350°F	1300
200°F	1535	400°F	1245
250°F	1440	450°F	1195
300°F	1370		

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COLD BOX SERVICE +100°F & BELOW 3000 PSIG MAX OWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/2" and Smaller	Sch. 80S, Seamless, Threaded Ends	ASTM A312 Tp 304
1" and Smaller	Sch. 40S, Seamless, Plain Ends	ASTM A312 Tp 304
1 1/2" thru 3"	Sch. 80S, Seamless, Plain Ends	ASTM A312 Tp 304
FITTINGS		
1/2" and Smaller	3000# Forged, Screwed Ends Warm Zone Only	ASTM A182 Gr F304
1" and Smaller	Sch. 40S, Forged, Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
1 1/2" and 2"	Sch. 80S, Forged, Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
2 1/2" and 3"	Sch. 80S, Wrought, Buttweld Ends	ASTM A403 WP 304 ASA B16.9
UNIONS		
1 1/2" and Smaller	Sch. 80S Forged, Ground Joint, Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
FLANGES		
2" thru 3"	1500# Forged, RTJ, Welding Neck, Bore for Sch. 80S	ASTM A182 Gr F304 ASA B16.5
BOLTING		
All Sizes	Studs, Full Thd., STSTL, Tp 304 Nuts, Hex, STSTL, Tp 321 (Alternate STSTL Tp 316)	ASTM A320 Sym B8 ASTM A194 Sym 8T
GASKETS		
All Sizes	RTJ, STSTL, Type 304, Oval, Maximum Brinell 140	ASA B16.20

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COLD BOX SERVICE +100°F & BELOW 3000 PSIG MAX OWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
VALVES		
GATE		
1" and Smaller	1500# Forged STSTL, Type 304, Socket Weld Ends	V-222B
1" and Smaller	Same - Extended Bonnet	EBV-222B
1 1/2" and 2"	1500# Forged STSTL, Type 304, Socket Weld Ends	V-215B
1 1/2" and 2"	Same - Extended Bonnet	EBV-215B
GLOBE		
1" and Smaller	1500# Forged STSTL, Type 304, Socket Weld Ends	V-722B
1" and Smaller	Same - Extended Bonnet	EBV-722B
1 1/2" and 2"	1500# Forged STSTL, Type 304, Socket Weld Ends	V-715B
1 1/2" and 2"	Same - Extended Bonnet	EBV-715B
CHECK		
2" and Smaller	1500# Forged STSTL, Type 304, Piston, Socket Weld Ends	V-1712B
GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	3000# OWG Forged STSTL, Type 304, Screwed Ends (Warm Zone Only)	V-719A

NOTE: 1. Threaded pipe and screwed fittings and valves are restricted to use in the Warm Zone only.

2. Bills of material must specify bore for buttweld end valves, and welding neck flanges.

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COLD BOX SERVICE +100°F & BELOW 3000 PSIG MAX OWG STAINLESS STEEL PIPE

NOTE: (Cont'd)

3. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 2". For detail bend radius data see Design Engineering Standard 578.30.1.1.

4. . .s standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	2820	350°F	2280
200°F	2690	400°F	2180
250°F	2520	450°F	2090
300°F	2400		

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Date Jan. 1964

COLD BOX SERVICE +100°F & BELOW 3600 PSIG MAX OWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/4"	Sch. 80S, Seamless, Threaded Ends	ASTM A312 Tp 304
3/4" and Smaller	Sch. 40S, Seamless, Plain Ends	ASTM A312 Tp 304
1" and 1 1/2"	Sch. 80S, Seamless, Plain Ends	ASTM A312 Tp 304
2"	Sch. 160S, Seamless, Plain Ends	ASTM A312 Tp 304
FITTINGS		
1/4"	6000# Forged Screwed Ends Warm Zone Only	ASTM A182 Gr F304
3/4" and Smaller	Sch. 40S, Forged, Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
1" and 1 1/2"	Sch. 80S, Forged, Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
2"	Sch. 160S, Wrought, Buttweld Ends	ASTM A403 WP 304 ASA B16.9
UNIONS		
1 1/2" and Smaller	Sch. 80S, Forged, Ground Joint, Socket Weld	ASTM A182 Gr F304 ASA B16.11
FLANGES		
2"	1500# Forged, RTJ, Welding Neck, Bore for Sch. 160S	ASTM A182 Gr F316 ASA B16.5
BOLTING		
All Sizes	Studs, Full Thd., STSTL, Tp 304 Nuts, Hex, STSTL, Tp 321 (Alternate STSTL Tp 316)	ASTM A320 Sym B8 ASTM A194 Sym 8T

APCI DOCUMENT NO 99001R2

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Date Jan. 1964

DESIGN ENGINEERING STANDARDS

570 PIPING

COLD BOX SERVICE +100°F & BELOW 3600 PSIG MAX CWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
GASKETS		
All Sizes	RTJ, STSTL, Type 304, Oval, Maximum Brinell 140	ASA B16.20
VALVES		
GATE		
1" and Smaller	1500# Forged STSTL, Type 316, Socket Weld Ends	V-223B
1" and Smaller	Same - Extended Bonnet	EBV-223B
1 1/2" and 2"	1500# Forged STSTL, Type 316, Socket Weld Ends	V-216B
1 1/2" and 2"	Same - Extended Bonnet	EBV-216B
GLOBE		
1" and Smaller	1500# Forged STSTL, Type 316, Socket Weld Ends	V-723B
1" and Smaller	Same - Extended Bonnet	EBV-723B
1 1/2" and 2"	1500# Forged STSTL, Type 316, Socket Weld Ends	V-716B
1 1/2" and 2"	Same - Extended Bonnet	EBV-716B
CHECK		
2" and Smaller	1500# Forged STSTL, Type 316, Piston, Socket Weld Ends	V-1713B
GLOBE (FOR PRESSURE GAUGE AND INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	5000# CWG Forged STSTL, Type 304, Needle, Screwed Ends (Warm Service Only)	V-712A

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Date Jan. 1964

COLD BOX SERVICE +100°F & BELOW 3600 PSIG MAX OWG STAINLESS STEEL PIPE

NOTE: 1. Threaded pipe and screwed fittings and valves are restricted to use in the Warm Zone only.

2. Bills of Material must specify bore for buttweld end valves and welding neck flanges.

3. The use of bends to replace ells will be permitted where sound judgment indicates an application on sizes up to and including 1 1/2". For detail bend radius data see Design Engineering Standard 578.30.1.1.

4. This standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	3480	350°F	2730
200°F	3220	400°F	2620
250°F	3020	450°F	2510
300°F	2880		

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Date Jan. 1964

COLD BOX SERVICE +100°F & BELOW 720 PSIG MAX OWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1/8" thru 3/8"	Sch. 80S IG Welded, Threaded Ends (Instrument Connections Only - See Note 4)	ASTM A312 Tp 304
1/2" and 3/4"	Sch. 40S, IG Welded, Threaded Ends (Instrument Connections Only - See Note 4)	ASTM A312 Tp 304
2 1/2" & smaller	Sch. 10S, IG Welded, Plain Ends	ASTM A312 Tp 304
3"	Sch. 10S, Seamless, Plain Ends	ASTM A312 Tp 304
4" thru 12"	Sch. 40S, IG Welded, Plain Ends	ASTM A312 Tp 304
FITTINGS (See Note 5)		
3/4" and smaller	2000#, Forged, Screwed Ends, Warm Zone Only (Instrument Connections Only - See Note 4)	ASTM A182 F304
2" and smaller	Sch. 10S, Wrought, Long Tangent Type with Belled Ends (1 1/2" and 2" Belled Tees are not Permitted)	ASTM A403 WP304L
1 1/2" & 2" (TEES)	Sch. 40S, Forged, Socket Weld Ends	ASTM A182 Gr F304 ASA B16.11
2 1/2" and 3"	Sch. 10S, Wrought, Buttweld Ends	ASTM A403 WP304L ASA B16.9
4" thru 12"	Sch. 40S, Wrought, Buttweld Ends	ASTM A403 WP304 ASA B16.9
UNIONS		
3/4" and smaller	2000#, Forged, Ground Joint, Screwed Ends, Warm Zone Only (Instrument Connections Only - See Note 4)	ASTM A182 F304
1 1/2" & smaller	Sch. 40S, Forged, Ground Joint, Socket Weld Ends	ASTM A182 F304 ASA B16.11

APCI DOCUMENT NO. 99000/87

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DESIGN ENGINEERING STANDARDS

570 PIPING

COLD BOX SERVICE +100°F & BELOW 720 PSIG MAX OWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
FLANGES		
2" thru 12"	300# Forged, 1/16" Raised Face, Welding Neck, Bore for Sch. of Pipe	ASTM A182 F316 ASA B16.5
BOLTING		
All Sizes	Studs, Full Thd., STSTL, Tp 304	ASTM A320 Sym B8
	Nuts, Hex, STSTL, Tp 321	ASTM A192 Sym 8T
	(Alternate STSTL Tp 316)	APCI 579.2.2
GASKETS		
All Sizes	Ring, Compressed Asbestos, 1/16" thick	ASA B16.21 APCI 579.2.3
VALVES		
GATE		
3/4" and smaller	300# Cast STSTL, Type 316, Screwed, Warm Zone Only	V-256A
2" and smaller	300# Cast STSTL, Type 316, Socket Weld Ends	V-256B
2" and smaller	Same - Extended Bonnet	EBV-256B
2 1/2" thru 12"	300# Cast STSTL, Type 316, Buttweld Ends	V-256C
2 1/2" thru 12"	Same - Extended Bonnet	EBV-256C
GLOBE		
3/4" and smaller	300# Cast STSTL, Type 316, Screwed Ends, Warm Zone Only	V-756A
2" and smaller	300# Cast STSTL, Type 316, Socket Weld Ends	V-756B
2" and smaller	Same - Extended Bonnet	EBV-756B
2 1/2" thru 8"	300# Cast STSTL, Type 316, Buttweld Ends	V-756C
2 1/2" thru 8"	Same - Extended Bonnet	EBV-756C

Air Products and Chemicals Inc

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Date Nov., 1967

COLD BOX SERVICE +100°F & BELOW 720 PSIG MAX OWG STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
VALVES (Cont'd)		
ANGLE		
3/4" and smaller	300# Cast STSTL, Type 316, Screwed Ends, Warm Zone Only	V-1256A
2" and smaller	300# Cast STSTL, Type 316, Socket Weld Ends	V-1256B
2" and smaller	Same - Extended Bonnet	EBV-1256B
2 1/2" thru 8"	300# Cast STSTL, Type 316, Buttweld Ends	V-1256C
2 1/2" thru 8"	Same - Extended Bonnet	EBV-1256C
CHECK		
3/4" and smaller	300# Cast STSTL, Type 316, Swing, Screwed, Warm Zone Only	V-1756A
2" and smaller	300# Cast STSTL, Type 316, Swing, Socket Weld Ends	V-1756B
2 1/2" thru 12"	300# Cast STSTL, Type 316,	V-1756C
GLOBE (FOR PRESSURE GAUGE & INSTRUMENT SHUT-OFF)		
1/4" and 1/2"	3000# OWG Type 304 Forged STSTL, Screwed Ends, (Warm Zone Only)	V-719A

NOTES: (SEE PAGE 4)

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DESIGN ENGINEERING STANDARDS

570 PIPING

COLD BOX SERVICE +100°F & BELOW 720 PSIG MAX CWG STAINLESS STEEL PIPE

NOTE:

1. Bills of Material must specify bore for buttweld end valves, and welding neck flanges.

2. The use of bends to replace ells will be permitted where sound judgement indicates an application on sizes up to and including 4". For detail bend radius data see Design Engineering Standard 578.30.1.1.

3. This standard can be used for temperatures above 100°F. The maximum PSI for elevated temperatures shall be as shown in the table below.

TEMP.	PSI	TEMP.	PSI
150°F	675	350°F	545
200°F	645	400°F	520
250°F	605	450°F	500
300°F	575		

4. Threaded pipe and fittings are restricted to use at instruments, pressure gauges, pressure taps, and safety valve connections only.

5. In sizes 6" thru 12", branch connections may be used where economically justified. Consult with piping squad leader and stress analyst prior to their use.

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LUBE OIL SERVICE -20°F to +150°F 150 PSIG MAX STAINLESS STEEL PIPE

This standard is for compressor, expander, compander, and other machinery lube oil service. Stainless steel pipe and fittings shall be used in that portion of the lube oil supply circuit from the oil filters to the bearings. CSl1.5 Design Engineering Standard 578.10.24, Carbon Steel Pipe, shall be used for all other lube oil circuits.

Provision shall be made for easy removal of lube oil piping in order to service the machines. Union or flanged joints shall be employed to provide a break at the machine and at the lube oil console. The lube oil system must have a complete and ready capability of disassembly for cleaning and maintenance.

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
1" and smaller	Sch. 40S, I.G. Welded, Plain and Threaded Ends (See Note 1)	ASTM A312 Tp 304
1 1/2" and 2"	Sch. 40S, I.G. Welded, Threaded Ends (See Note 1)	ASTM A312 Tp 304
1 1/2" thru 12"	Sch. 10S, I.G. Welded, Plain Ends	ASTM A312 Tp 304
FITTINGS (See Notes 1 and 2)		
2" and smaller	2000# Forged, Screwed Ends (See Note 1)	ASTM A182 Gr. F304 ANSI B16.11
1" and smaller	3000# Forged, Socket Weld Ends	ASTM A182 Gr. F304 ANSI B16.11
1 1/2" and 2"	Sch. 10S, Wrought, Long Tangent Type with Belled Ends	ASTM A403 WP304L
2 1/2" thru 12"	Sch. 10S, Wrought, Buttweld Ends	ASTM A403 WP304 ANSI B16.9
UNIONS		
1" and smaller	3000# Forged, Ground Joint, Socket Weld Ends	ASTM A182 Gr. F304 ANSI B16.11
FLANGES		
1 1/2" thru 12"	150# Forged, Carbon Steel, Slip On, Flat Face	ASTM A181 Gr. 1 ANSI B16.5

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Date 10/15/71

APCI DOCUMENT NO. 99000182

DESIGN ENGINEERING STANDARDS

570 PIPING SSL1.5

LUBE OIL SERVICE -20°F to +150°F 150 PSIG MAX STAINLESS STEEL PIPE

ITEM	DESCRIPTION	SPECIFICATION
BOLTING		
All sizes	Bolts, Carbon Steel, Full Thread	ASTM A307 Gr. B
	Nuts, Carbon Steel, Hex	ASTM A194 2H
GASKETS		
All sizes	Full Face Compressed Asbestos, 1/16" Thick	ANSI B16.21
VALVES (See APCI Design Eng. Std. 579.3)		
GATE		
2" and smaller	125# Bronze, Screwed Ends	V-12A
2 1/2" thru 12"	125# IBBM, Flat Face Flanged Ends	V-45F
GLOBE		
2" and smaller	150# Bronze, Screwed Ends	V-511A
2 1/2" thru 12"	125# IBBM, Flat Face Flanged Ends	V-550F
CHECK		
2" and smaller	125# Bronze Swing, Screwed Ends	V-1501A
2 1/2" thru 4"	125# IBBM, Swing, Flat Face Flanged Ends	V-1541F
6" thru 12"	125# Wafer Type, IBBM Buna-N Seals, Flat Face End Connection	Mission 12HMP
BALL		
2" and smaller	150# Bronze or Brass, Teflon Seats and Seals, Threaded Ends	V-3001A
GLOBE (For Pressure Gauge and Instrument Shut-Off)		
1/4" and 1/2"	400# OWG Bronze, Screwed Ends	V-2011A

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Date 10/15/71

LUBE OIL SERVICE -20°F to +150°F 150 PSIG MAX STAINLESS STEEL PIPE

NOTES 1. Weld fittings shall be used wherever possible. The use of screwed end fittings shall be limited to instrument, equipment, or valve connections.

2. The use of bends to replace ells is permitted where sound and economic judgement indicates an application. Bends shall conform to ANSI B31.3.

3. Nominal pipe sizes 1 1/4, 3 1/2, 5 and 7 inch shall not be used.

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Date 10/15/71

INTRODUCTION — HAND VALVE CODE

1. PURPOSE

Standard 579.3 provides for the specification of hand valves and is issued to facilitate the preparation of Bills of Material, requisitions, purchase orders, and inventory records.

2. SCOPE

Standard 579.3 specifies commercially manufactured hand valves, excluding the extended bonnet type (579.4). This introduction includes:

A. The method of designation

B. The use of designators

C. Purchase requisitions

D. Table of Valves styles and materials

E. Table of valve end designations

3. METHOD OF DESIGNATIONS

All valves appearing on flow sheets carry a number. These valves are numbered consecutively for each project in the development of the flow sheet. These are not designation numbers, but do appear on the piping drawings.

After selection of the proper piping material for a given service, the use of the correct Air Products and Chemicals, Inc. Piping Standards will determine the proper valve to be used and will give its designation number and suffix. The letter "V" is here used, appearing as a prefix to all valve numbers.

The number following the "V-" indicates the style of the valve and the type of body material; these numbers are defined in Table 1 of this Introduction.

A suffix letter indicates the type of end connection. The suffix letters are shown on Table 2 of this Introduction.

APCI DOCUMENT NO. 99000/83

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3. METHOD OF DESIGNATIONS (Cont'd)

Example: A valve carrying the designation 4" V-131G is a cast steel gate valve with raised face flanged ends. In the following catalog section this valve is shown to be 720# CWG service, and is available as Bolted Bonnet, OS&Y, Rising Stem, Solid Wedge, Inserted Seats, from the following manufactureres, with catalog numbers listed.

Darling	S-72 OS&Y	Lunk'hmr	1938-B6
Powell	3003	RP & C	3001
Jenkins	1010-CM	Pacific	350-[illegible]
Crane	33XR	Walworth	5206F

4. USE OF DESIGNATORS

The valve designator describes any valve fully, except for size. It is to appear on the following:

A Valve Summary

B. Line and Valve Consolidated Bills of Material

C. Purchase Requisition

D. Purchase Order

The manufacturer will attach a metal tag which shall bear the valve designator (also called valve tag number). This tag will facilitate the work of the shops or field erectors.

5. PURCHASE REQUISITION/ORDER

The valve requisition will list only quantity, size, designator and tagging instructions. The listing will start with the smallest designator and progress to the largest. This will automatically place the valves in order so that like type and material categories can be easily recognized by referring to Table 1, below. The Purchasing Department transmits copies of the final typed requisition to Vendors for quotation.

Listing of valves on Purchase Orders will follow requisitions, i.e., by increasing designator number, giving only quantity, size, designator and tagging instructions.

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INTRODUCTION HAND VALVE CODE

6. VALVE STYLES AND MATERIALS

TABLE I

BODY MATERIAL AND RANGE OF TAG NUMBERS

TYPE OF VALVE	BRONZE	CAST IRON	FORGED OR CAST STEEL	FORGED OR CAST STSTL	ALUMINUM
Gate	1-40	41-60	61-180	181-300	301-340
Globe	501-540	541-560	561-680	681-800	801-840
Angle	1001-1040	1041-1060	1061-1180	1181-1300	1301-1340
Check	1501-1540	1541-1560	1561-1680	1681-1800	1801-1840
Needle	2001-2040	2041-2060	2061-2180	2181-2300	2301-2340
Plug	2501-2540	2541-2560	2561-2680	2681-2800	2801-2840
Ball	3001-3040	3041-3060	3061-3180	3181-3300	3301-3340
Butterfly	3501-3540	3541-3560	3561-3680	3681-3800	3801-3840

7. VALVE END DESIGNATIONS

TABLE II

A - Screwed-U.S. Std. Taper
B - Socket Weld
C - Buttweld
D - Solder (For OD Tubing)
E - Silver Braze (For Iron Pipe Size)
F - Flanged, Flat Face
G - Flanged, Raised Face
H - Flanged, Ring Joint
J - Flanged, Large Male
K - Flanged, Large Female
L - Flanged, Small Male
M - Flanged, Small Female
N - Flanged, Large Tongue
P - Flanged, Large Groove
Q - Flanged, Small Tongue
R - Flanged, Small Groove
S - Flanged, Ammonia
T - SAE Flare
U - Screwed-U.S. Std. Parallel
V - Compression
W - Screwed-B.S.P. Parallel
Z - Screwed-B.S.P. Taper

8. GENERAL

Booklets containing valve designator sheets have been prepared by the Standards Department for distribution to the valve vendors. It is intended that these booklets will be used by the vendors to interpret Purchase Requisitions and Purchase Orders.

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SERVICE -20°F TO +150°F (See Note 1) 150 PSIG MAX OWG CARBON STEEL

Air Nitrogen
Glycol Water

ITEM	DESCRIPTION	SPECIFICATION
PIPE		
2" and smaller	Std. Buttweld, Threaded Ends (See Note 2)	ASTM A53
4" and smaller	Std. Buttweld, Plain Ends	ASTM A53
6"	Std. Seamless, Plain Ends	ASTM A53 Gr B
8" thru 12"	Sch. 20 Seamless, Plain Ends	ASTM A53 Gr B
14" thru 24"	Sch. 10 Seamless, Plain Ends	ASTM A53 Gr B
FITTINGS (See Note 3)		
2" and smaller	2000# Forged Steel Threaded Ends (See Note 2)	ASTM A181 Gr 2 ANSI B16.11
2" and smaller	3000# Forged Steel, Socket Weld Ends	ASTM A181 Gr 2 ANSI B16.11
2 1/2" thru 6"	Std. Wt. Wrought Steel, Buttweld Ends	ASTM A234 WPB
8" thru 12"	Sch. 20 Wrought Steel, Buttweld Ends	ASTM A234 WPB
14" thru 24"	Sch. 10 Wrought Steel, Buttweld Ends	ASTM A234 WPB
UNIONS		
2" and smaller	2000# Forged Steel, Ground Joint, Steel-to-Steel Seats, Threaded Ends (See Note 2)	ASTM A181 Gr 2 ANSI B16.11
2" and smaller	3000# Forged Steel, Ground Joint, Steel-to-Steel Seats, Socket Weld Ends	ASTM A181 Gr 2 ANSI B16.11
FLANGES		
1/2" thru 2"	150# Forged Steel, Flat Face, Socket Weld	ASTM A181 Gr 1 ANSI B16.5

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APCI DOCUMENT NO. 99000184

DESIGN ENGINEERING STANDARDS

570 PIPING CS 1.5

SERVICE: -20°F to +150°F (See Note 1) 150 PSIG MAX OWG CARBON STEEL

Air Nitrogen
Glycol Water

ITEM	DESCRIPTION	SPECIFICATION
FLANGES (Cont'd)		
2 1/2" thru 24"	150# Forged Steel, Flat Face, Slip-On (See Note 5)	ASTM A181 Gr 1 ANSI B16.5
2 1/2" thru 24"	150# Forged Steel, Flat Face, Welding Neck, Bore for Sch. of Pipe (See Note 5)	ASTM A181 Gr 1 ANSI B16.5
BOLTING		
All sizes	Bolts, Carbon Steel, Full Thd. Nuts, Carbon Steel, Hex	ASTM A307 Gr B ASTM A194 2H
GASKETS		
All sizes	Full Face, Compressed Asbestos 1/16" thick	ANSI B16.21
VALVES (See APCI Design Eng. Std. 579.3)		
GATE		
2" and smaller	125# Bronze, Threaded Ends	V-12A
2 1/2" thru 24"	125# IBBM, Flat Face, Flanged Ends	V-45F
GLOBE		
2" and smaller	150# Bronze, Threaded Ends	V-511A
2 1/2" thru 12"	125# IBBM, Flat Face Flanged Ends	V-550F
CHECK		
2" and smaller	125# Bronze, Swing, Threaded Ends	V-1501A
2 1/2" thru 4"	125# IBBM, Swing, Flat Face Flanged Ends	V-1541F
6" thru 24"	125# Wafer Type, IBBM, Buna-N Seals, Flat Face End Connection	Mission 12HMP (See Note 1)

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Date 10/15/71

DESIGN ENGINEERING STANDARDS

570 PIPING CS 1.5

SERVICE -20°F to +150°F (See Note 1) 150 PSIG MAX OWG CARBON STEEL

Air Nitrogen
Glycol Water

ITEM	DESCRIPTION	SPECIFICATION
BALL		
2" and smaller	150# Bronze or Brass, Teflon Seats and Seals, Threaded Ends	V-3001A (See note 6)
2" and smaller	1000# OWG Steel, Teflon Seats and Seals, Socket Weld Ends	V-3061B
2 1/2" thru 6"	150# Ductile Iron, Teflon Seats and Seals, Raised Face Flanged Ends	V-3041G
GLOBE (For Pressure Gauge and Instrument Shut-Off)		
1/4" and 1/2"	400# OWG Bronze, Threaded Ends	V-2011A

NOTE: 1. This standard can be used for temperatures above 150°F. The maximum PSI for elevated temperatures shall be as shown in the table below. (The component limiting pressure is Cast Iron flanged valves - ANSI B16.1).

TEMP.	PSIG	TEMP.	PSIG
200°F	135	300°F	110
250°F	125	350°F	100

Mission check valve 12 HMP which use Buna N seals, shall be used up to 200°F. For temperatures between 201°F and 350°F, use Mission figure 12HVP which utilizes Viton "A" seals.

2. Weld fittings shall be used wherever possible. The use of screwed end fittings and unions shall be limited to instrument, equipment, or valve connections.

3. The use of bends to replace ells is permitted where sound and economic judgment indicates an application. Bends shall conform to ANSI B31.3. Effect of bends on the stress analysis of the system must be considered.

4. Nominal pipe sizes 1 1/4, 3 1/2, 5 and 7 inch shall not be used.

5. Slip-on flanges should normally be used rather than welding neck due to economy. Welding neck flanges shall be used in piping subject to pressure pulsations as with reciprocating compressors.

6. Use for dead end service. Use V-3061B for in-line service.

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Date 10/15/7-

Air Products and Chemicals, Inc.

PUT IT IN WRITING

Date: April 27, 1965

TO: R. E. Sotak

FROM: R. H. Foster

Subject: Cold Test of 1/2" Safety Valve with Carbon Steel Spring, WO 10-7071, Project 00-5-3246-51.12.50
TECHNICAL MEMORANDUM #79

cc: W. L. Ball
A. Lapin
C. McKinley/R. Flinn
S. Paterno
C. J. Schilling

Objective of Test

To determine the applicability of a carbon steel safety valve spring in cold service.

Summary of Results

The spring was first cycled mechanically 12,960 strokes, for the full lift of the safety valve, while emmersed in liquid nitrogen. It was then cycled by pressure 25 times, starting with a warm valve which cooled during operation by cold gas passing through it. Thirdly, three nicks were placed near the ends and at the center of the spring, and the valve was cycled mechanically, while immersed in liquid nitrogen, for 2,285 strokes.

No changes in the mechanical characteristics of the spring could be detected. The relief pressure remained the same as at the start. The seating pressure decreased, but this could have been a transitory effect at the first test. The nicking of the spring had no discernible effect.

The carbon steel spring is apparently satisfactory for the use down to at least -320°F.

PCI DOCUMENT
D 990078S

Test Procedures

A. Long-Term Cycling

A 1/2" size Kunkle safety valve (Fig. 23A) was first pressure tested to determine its new-condition characteristics. It was then fastened to a steel framework in such a manner that the lever arm of the safety valve could be operated by a rod extending from a small air piston. The safety valve was then immersed in liquid nitrogen, and air was applied in a cyclic pattern to the piston operator. This assembly was operated for the full available stroke of the valve lift mechanism at about 20 strokes per minute for a total of 15,245 strokes as outlined in Table 1:

Table 1

Strokes	Relief Pressure	Seating Pressure
0	98	72
5,920	98	94
12,960	98	93.5
15,245*	98	93.5

*After nicking of spring at 12,960 cycles.

After 12,960 strokes, the safety valve was partially disassembled and the [illegible]/32" diameter coil spring was nicked 1/32" deep at the center and near each end. It was reassembled and cycled 2,285 times with no apparent mechanical changes.

B. Cold Gas Test

In this test, the valve was suspended well above a liquid nitrogen bath. The nitrogen line leading to the safety valve was coiled and immersed in liquid nitrogen. Thus, the gas which caused the valve to operate was cooled to near liquid nitrogen temperature. The valve was operated about 25 times with various periods of warming between operations.

At times the valve was cold enough to emit liquid nitrogen, since the line pressure was 160 psig during no-flow conditions. Many times the entire valve was frosted as a result of operation.

Discussion of Test Results

As indicated in the summary, no apparent mechanical changes occurred in the spring. As is indicated by Table 1, the spring rate did not change, either as a result of cooling down to liquid nitrogen temperature, or as a result of cycling at that low temperature. Several times, during the cold gas test, the valve tended to freeze open as ice formed around the seat opening. The action of the valve became sluggish due to apparent binding of the spring. However, these effects are dependent only on the design of the valve and not to the presence of a carbon steel spring.

Conclusions

It may be concluded from this that a carbon steel spring may be used in safety valves which during operation exhaust cold gas down to -320°F.

Test data, flowsheet and pictures may be reviewed in R&D Notebook 1237.

ORIGINAL SIGNED BY

R. H. Foster

RHF:kfd

(Retyped 9/25/72 sba)

Air Products and Chemicals INC

PUT IT IN WRITING

Date April 17, 1961

TO L. Ball

FROM E. Kehat

SUBJECT Burning of Steel Pipes in a Flowing Oxygen Stream

cc: Geist, J.
McKinley, C.

INTRODUCTION

Oxygen flowing in a steel pipe, heated at one point to redness, reacts with the iron in the pipe to form the oxide - FeO. The melting temperature of this oxide (1420°C) is lower than that of steel (1535°C) and therefore the oxide can melt, fall off and expose new surface of the steel pipe for further oxidation. The reaction proceeds at a fast rate and is essentially an iron flame.

A short experimental program was undertaken to evaluate the effect of pipe size and rate of oxygen flow in a pipe that is open to the atmosphere, on the linear burning rate of steel.

EXPERIMENTAL

Pressure regulated oxygen was discharged from a cylinder through the pipe section on the test stand. The pipe section was heated at the outlet with an acetylene torch till it started to burn. A long section of copper tubing dissipated the expansion cooling between the regulator and the pipe section.

Flow was controlled by the pressure at the regulator and was measured by a stop watch and the change of pressure in the cylinder during a run. The rate of linear burning of the pipe was measured by a stopwatch and the decrease in length of pipe during a run.

RESULTS

Sixty-five runs were made. Pipe sizes were 1/4", 1/2" and 1". Initial pressures ranged from 10 to 300 psig and flow rates from 1 to 12 CFM oxygen. Pipe burning

APCI DOCUMENT NO. 92000186

rates ranged from 0.5 - 1.75 ft/min. Reproducibility was poor and in all cases, except one, the flame extinguished itself after 1 - 40 seconds, having burned from 1/2" - 6" lengths of pipe. In one run with 1/4" pipe, 12" of pipe was burned. A water hose was turned on the pipe and the flame was quenched in about 10 seconds.

The flow measuring system was poor and the larger pipes burned on the underside only. No difference in burning behaviour was noted whether the flame was initiated by heating one spot or by heating a narrow band on the circumference of the pipe, or by using smaller or larger sized torches.

In most cases the initial burning rate was fast. The flame subsequently slowed down and either rekindled occasionally into a fast flame or extinguished itself.

The following table was constructed by interpolation of a large number of scattered data points and should only be used as a rough approximation.

TABLE I.

LINEAR BURNING RATE OF PIPE AS A FUNCTION OF PIPE SIZE AND OXYGEN FLOW RATE

Oxygen Flow Rate (CFM)	Linear Burning Rate - ft/min.		
	1/4"	1/2"	1"
1	.5	.14	.1
2	1.0	.3	.2
4		.6	.4
6		.9	.6
8		1.1	.8
10		1.4	1.0
12		1.7	1.2

DISCUSSION

Like any other flame, continued propagation is dependent on the heat transfer rate to the unburnt pipe and elimination of the combustion products from the combustion area. A slight drop in the heat transfer rate due to external cooling from air currents or fluctuations in the oxygen temperature will slow down the flame to the point where the FeO does not melt and fall off and the flame will extinguish itself. However, if

some combustible material is available; extra carbon from the steel pipe or some oil trace inside the pipe, the temperature of the flame will go up, the FeO will continue to melt and the flame will continue to propagate.

The pipe sections used in the experiments had been cleaned and degreased, which may have helped to extinguish the flame.

During the experiments, it was observed that for each size of pipe there was some optimum oxygen flow for continued combustion, above which the cooling from the excess oxygen extinguished the flame. However, a plot of burning rate versus oxygen flow rate showed, despite the large scatter, that the burning rate of the pipe increased with oxygen flow rate over the whole range of experiments.

Increasing the pipe size decreased the linear burning rate and the time before the flame extinguished itself.

CONCLUSIONS

1. Clean steel pipe burning in an oxygen stream tend to extinguish the flame.

2. Burning steel pipe can be extinguished by water.

3. The linear burning rate of the pipe increases with increase in oxygen flow and decrease in pipe size.

E. Kehat

EK:faj

Retyped 10/19/72 cju

REPRODUCIBILITY OF THE ORIGINAL COPY IS POOR.

Test No.	Pipe Size Inches	O_2 Press.	O_2 Flow Initial Press. PSIG	O_2 Flow Final Press. PSIG	Time Interval Seconds	Flow CFM	Rate of Burning Length Burned Inches	Rate of Burning Time Seconds	Rate of Burning Approx. Burning Rate Ft./Min.	
1.	½	150	—	—	23	5	—	—	—	
2.	½	50	—	—	5	—	—	—	—	
3.	½	100	—	—	20	12	—	—	—	
4.	½	50	—	—	—	—	—	1	—	
5.	½	50	—	—	18	5	—	—	—	
6.	½	35	—	—	—	—	—	—	—	
	INSTALLED A 10' ¼" Cu. LINE TO WARM UP GAS AFTER J.T. EFFECT FRO									
7.	½	35	—	—	—	—	—	—	—	
8.	½	40	1845	1832	38	2.08	—	2	—	
9.	½	100	1832	1775	60	5.7	1	—	—	
10.	¼	20	1795	1783	67	.9	4.75	38	.625	
11.	¼	40	1783	1775	26	1.85	—	—	—	
12.	¼	40	1775	1758	44	2.32	—	—	—	
13.	¼	1[illegible]	1758	1745	39	2.0	—	1	—	
14.	¼	100	1748	1725	25	5.52	—	2	—	
15.	¼	30	1725	1709	65	1.48	6.0	36	.833	
16.	¼	35	1710	1698	44	1.64	—	—	—	
17.	¼	25	1697	1693	37	.97	2.0	20	.5	
18.	¼	23	1685	1683	14	.86	—	—	—	
19.	Ran the above test only we heated larger area to initiate burning - No data									
20.	¼	35	1677	1650	95	1.7	12	95	.65	
21.	¼	150	—	—	—	—	—	—	—	
22.	¼	35	Tried to duplicate burning as in test # unsuccessful							
23.	¼	35								
24.	¼	35	1570	1540	81	2.2	—	—	—	
25.	¼	35	1538	1523	81	1.1	—	—	—	
26.	½	35	1525	1505	76	1.58	.5	53	.475	
27.	½	145	1505	1463	42	9.0	—	8	—	
28.	½	60	1462	1440	45	2.93	1.0	30	.17	
29.	½	75	1450	1425	45	4.66	—	15	—	
30.	½	80	1425	1395	45	4.0	1.75	15	.58	
31.	½	90	1395	1356	59	3.96	3.5	23	.76	
32.	½	100	1368	1326	48	5.25	2.5	17	1.03	
33.	½	100	1330	1305	33	4.54	1.5	6	1.25	
34.	½	90	1305	1278	37	4.38	1.5	10	.75	
35.	½	80	1280	1245	41	5.12	—	—	—	
36.	½	85	1253	1230	33	4.18	1.25	3	2.08	

(continued)

Test No.	Pipe Size Inches	O_2 Press.	O_2 Flow Initial Press psig	O_2 Flow Final Press psig	Time Interval Seconds	Flow CFM	Rate of Burning Length Burned Inches	Rate of Burning Time Seconds	Rate of Burning Average Burning Rate Ft/Min.	Remarks
37	½	80	1255	1170	85	5.36	3.75	13	1.44	Trial run in
38	½	90	1170	1150	31	3.87	2.75	10	1.38	
39	½	70	1150	1130	40	3.0	2.0	10	1.0	Metal strip
40	½	74	1134	1118	40	2.4	2.5	10	1.25	Paint smoke
41	½	74	1118	1100	34	1.41	.75	10	4.5	← A.B.R. Re
42	½	74	1100	1079	49	2.59	1.5	10	.75	
			New Pipe Section Installed For Testing							
43	½	74	—	1076	30	—	—	—	—	Initial Press
44	½	74	1078	1057	39	3.23	1.25	14	.46	
45	½	80	1058	1043	27	3.33	.75	8	.47	Burning seam
46	½	90	1045	1023	29	4.55	1.75	11	.80	
47	½	90	1025	1009	—	—	1.0	8	.61	
48	½	85	1010	995	26	3.46	1.5	8	.37	
49	½	85	995	983	23	3.13	1.5	6	1.25	Started Paint Run #3 a.m.
50	½	120	985	943	40	6.3	2.5	20	.625	
51	½	120	950	925	28	5.36	1.5	8	.983	
52	½	120	925	907	25	4.32	1.25	7	.89	
53	½	150	907	882	23	6.5	1.5	6	1.25	
54	½	150	883	846	35	6.34	1.25	7	.89	
55	½	200	854	800	33	9.81	2.50	12	1.04	Burn mark
56	½	200	800	775	20	7.5	2.10	6	1.75	
57	½	250	795	750	23	11.74	1.0	5	4.0	
58	½	250	750	720	17	10.59	.5	4	.623	
59	½	150	720	695	28	6.36	.75	12	.31	
60	1	150	700	670	29	6.2	1.0	6	.833	
61	1	100	668	643	34	4.41	—	—	—	
62	1	200	646	608	24	9.50	1.0	5	1.0	Bottom half
63	1	250	610	570	23	10.35	1.0	5	1.0	
64	1	300	575	503	37	11.69	2.0	16	.625	
65	1	300	505	463	24	10.5	1.0	2	2.5	← ?

NOTE: PIPE SIZE ½" UNLESS NOTED

TEST No.	PIPE CONDITION	O_2 FLOW CORRECTED CFH. (PSIG)	BURNING TIME SEC.	LENGTH BURNED INCHES	AVERAGE BURNING RATE FT/MIN.	REMARKS
1.	DEGREASED & PAINTED	8.94 (200)	26	2¾	.529	
2.	"	9.42 (200)	2	¼	.625	Figured out.
3.	"	8.24 (200)	10	1½	.75	
4.	"	11.79 (250)	6	~	—	Burned only on leading edge, not.
5.	USED GALVANIZED	11.79 (250)	155	16	.516	
6.	CLEANED PIPE	11.79 (250)	17	2	.590	
7	"	11.79 (250)	37	4½	.608	Started the burning in the middle
8.	OLD USED PIPE, NOT GALV.	11.79 (250)	13	3½	1.35	
9.	"	9.19 (250)	9	1	.556	
10.	"	13.67 (300)	6	1	.833	
11.	"	7.21 (300)	12	~	—	
12.	"	10.09 (300)	—	—	—	Used O_2 burning tip on outside of through pipe — Pre burning
13.	GALV. INSIDE & OUTSIDE USED, OUTSIDE BRUSHED CLEAN	12.23 (300)	29	6¾	1.164	
14.	USED PIPE NOT GALV.	12.23 (300)	10	1	.50	
15.	DEGREASED ⅛" W.P.S.	3.08 (150)	6	NOT MEASURED	—	
16.	"	5.13 (150)		"	—	
17.	"	1.54 (150	15	"	—	

Output (CFM)	Pipe Size			
	½" (Sched 40)		1" (Sched 40)	
	Velocity (FPS)	Friction Loss (FT/100)	Velocity (FPS)	Friction Loss (FT/100)
1	$\frac{1 FT^3}{1 MIN} \times \frac{1 MIN}{60 SEC} \times \frac{144 IN^2}{.304 IN^2 FT^2}$ = 1.9 FPS	.14	$1 \times \frac{144}{.546} \times \frac{1}{60}$ = .5 FPS	.1
2	15.8	.3	5.56	.2
4	31.6	.6	11.10	.4
6	47.3	.9	16.70	.6
8	63.0	1.1	22.20	.8
10	79.0	1.4	27.80	1.0
12	94.6	1.7	33.3	1.2

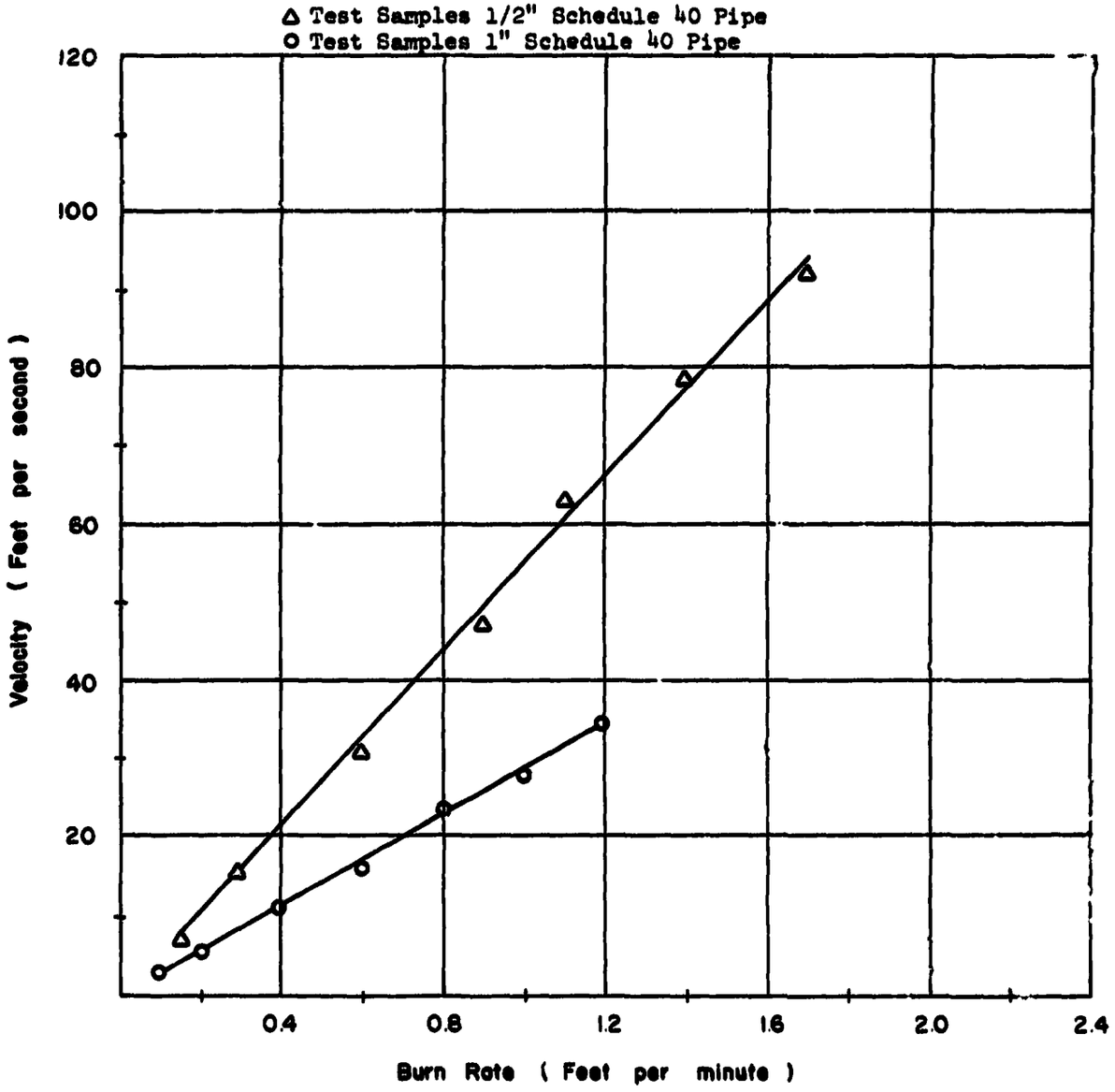
Notes:

Velocity is based on actual pressure drop thru

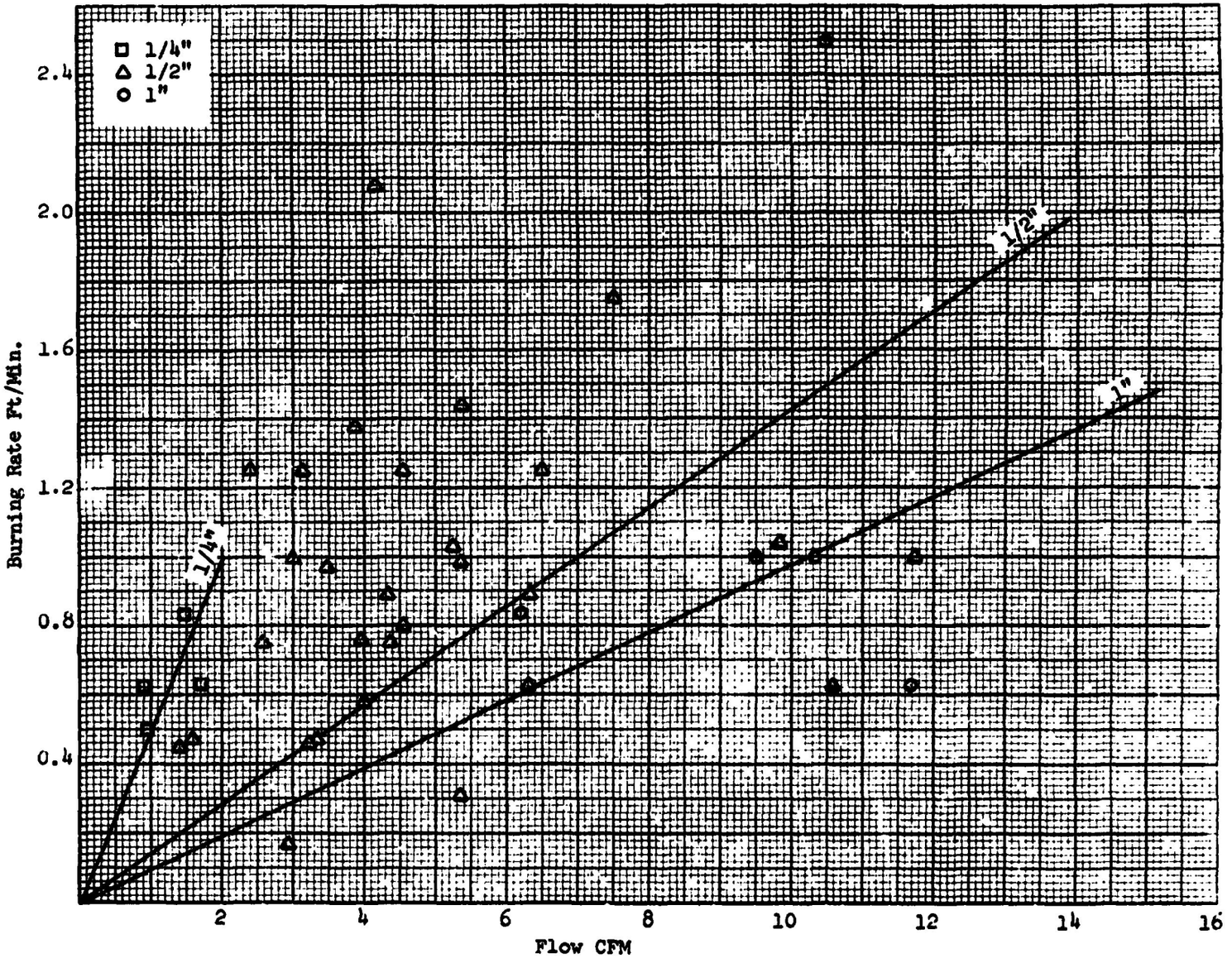
Oil used [illegible]

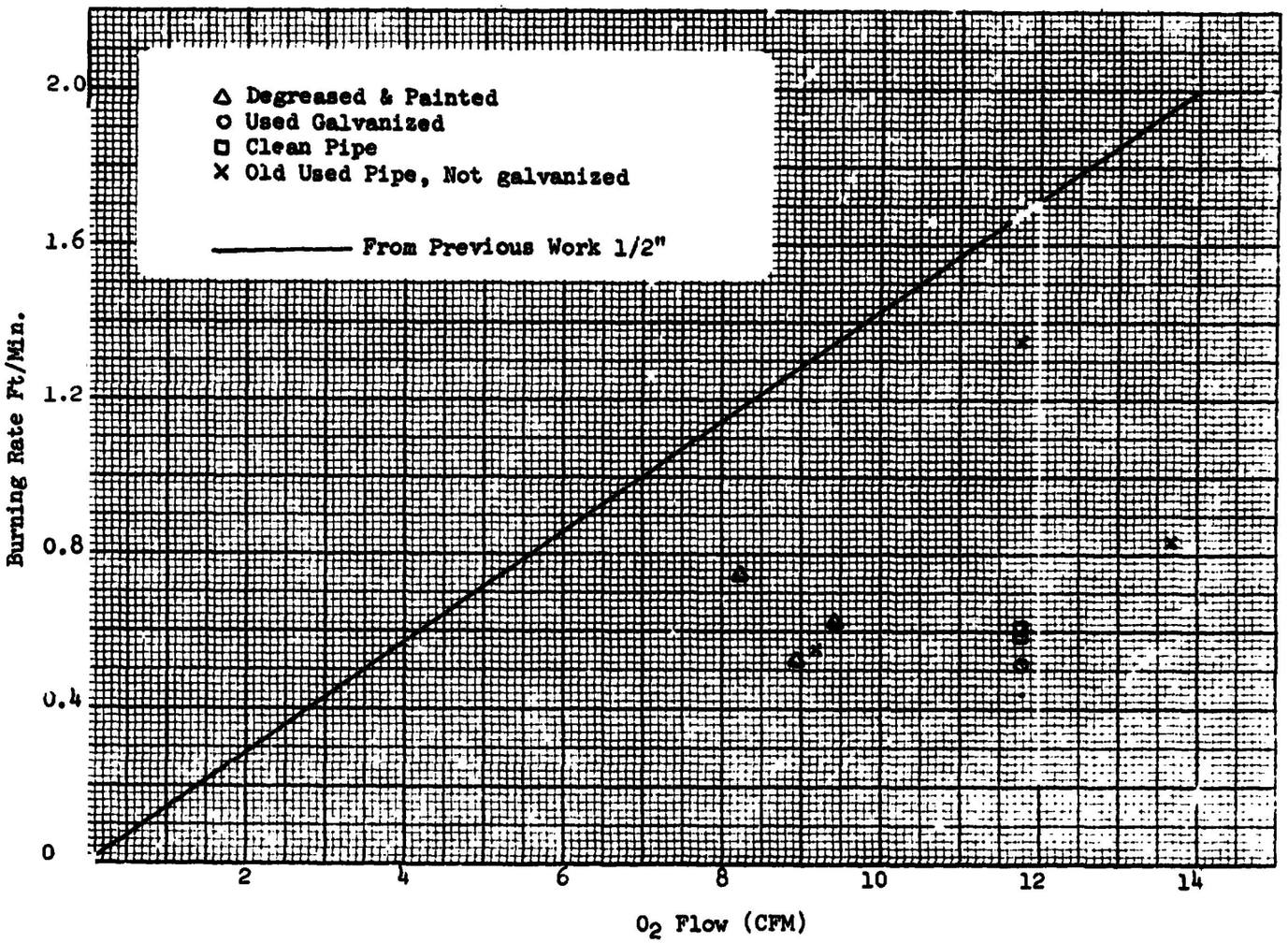
[illegible]

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Burning of Carbon Steel Lines in O_2 Service


□ 1/4"
△ 1/2"
○ 1"
Burning Rate Ft/Min.
2.4
2.0
1.6
1.2
0.8
0.4
1/4"
1/2"
1"
2
4
6
8
10
12
14
16
Flow CFM


△ Degreased & Painted
○ Used Galvanized
□ Clean Pipe
× Old Used Pipe, Not galvanized
From Previous Work 1/2"
Burning Rate Ft/Min.
2.0
1.6
1.2
0.8
0.4
0
2
4
6
8
10
12
14
O2 Flow (CFM)

Air Products and Chemicals INC.

COMPANY CONFIDENTIAL

IGNITION LIMITS OF CARBON STEEL IN OXYGEN-NITROGEN ATMOSPHERES

IWO LB-0043

Technical Memorandum No. 112

May 8, 1968

B. Bailey

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Bruce Bailey 5/24/68
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PCI DOCUMENT
D 99000 187

I. Introduction

A memo concerning a reaction in the reciprocating nitrogen recycle compressor system of an air plant recently (1) suggested an investigation into the limits of flammability of carbon steel in an atmosphere of various mixtures of nitrogen and oxygen. This has been a recurrent problem in air plant design and some of its aspects have been examined by others. Kehat (2) studied the burning of steel pipes in which oxygen was flowing. This work was mainly to determine the burning rate of an oxygen carrying pipe in ambient air and was not concerned with the oxygen concentration at the reacting interface.

Kitson (3) made a literature review on this topic and tabulated ignition temperatures of several steels in oxygen at various pressures. This work noted that the information pertaining to carbon steels was questionable since lower ignition temperatures were cited in some cases in air than in oxygen. No work was cited which studied the limiting oxygen concentration in which the burning of carbon steel would be self-propagating.

This program investigates a method for determining this limiting concentration. The pressure of first importance for this work was 900 psig, the pressure at which the reaction occurred in the air plant compressor.

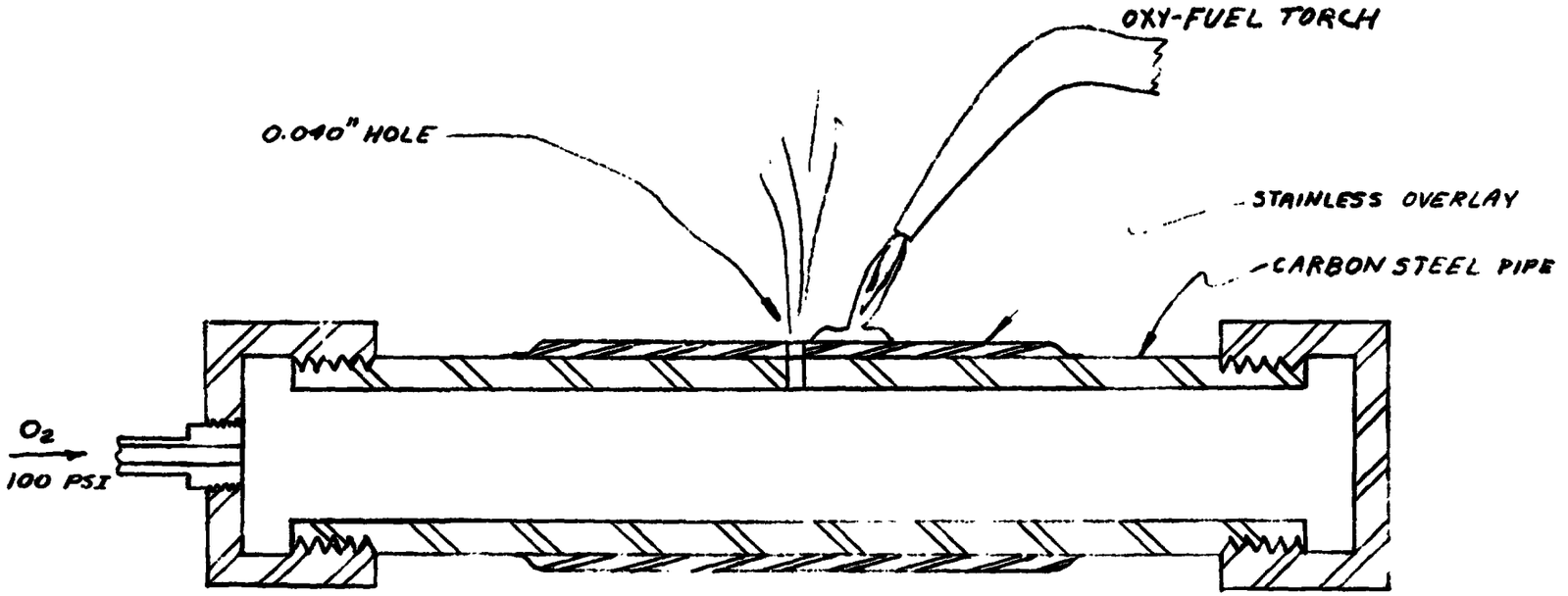
II. Experimentation

The first series of tests attempted to initiate the burning of a carbon steel pipe by heating a point on the wall of the pipe in which a flowing stream of oxygen-nitrogen mixture was maintained. Ignition was not achieved on the inside of the pipe even with commercially pure oxygen. When ignition did occur, it started on the outside of the pipe near the exit hole and propagated to the inside.

An effort was made to prevent the ignition on the outside of the pipe by first cladding it with a layer of type 308 stainless steel as shown in Figure 1. This test did not produce ignition of the carbon steel pipe even though a molten pool of metal was established with a welding torch on the outside of the pipe containing oxygen at 100 psig and maintained there for several minutes.

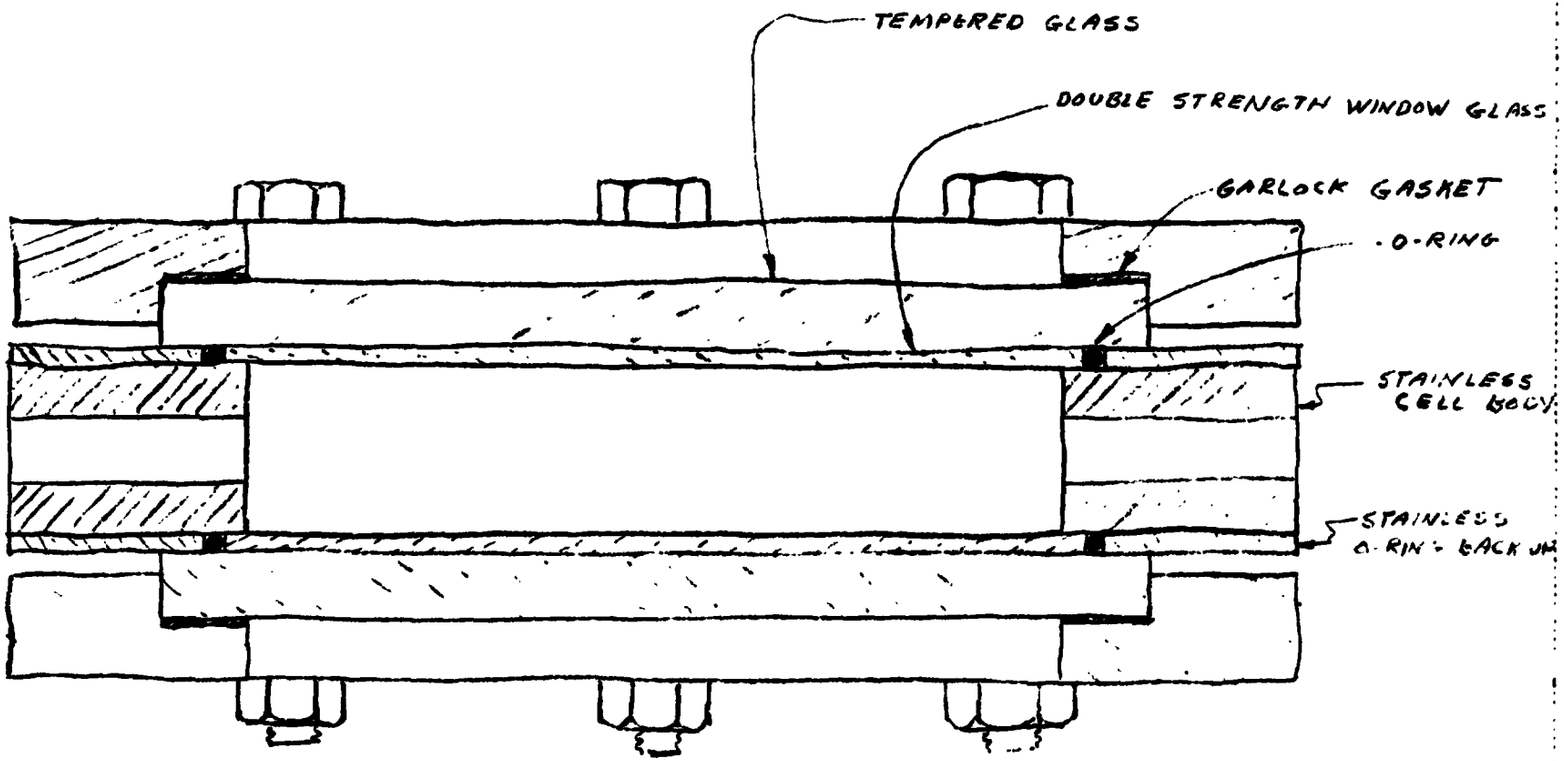
The results of these two tests indicated that the test sample should be enclosed in a chamber maintained at the concentration and pressure of interest at the point where the ignition energy is applied. Kehat (4) in an earlier work had used the spark from a Model T Ford ignition coil to produce ignition in a pressurized chamber, but in that experiment he was only igniting vapors so it appeared appropriate to use a higher energy spark in this test such as the output from an arc welding power supply.

A high pressure reaction chamber was fabricated as shown in Figure 2, to withstand a working pressure of 2900 psig at room temperature. It had a reaction space 5/8" x 1" x 4-1/2" and was equipped with a viewing window and an electrical lead-through. The sample used was a short



ATTEMPTED IGNITION OF STAINLESS CLAD PIPE

FIGURE 1



HIGH PRESSURE REACTION CHAMBER

FIGURE 2

length of 1/4" O.D. mild steel tubing. A high pressure regulator was used with a "D" size gas sample cylinder to provide a flow of gas through the cell at the desired pressure and a metering valve on an outlet line from the cell controlled the flow rate. A tungsten electrode was connected to the electrical leadthrough and the sample was grounded to the chamber wall which was connected to a lead to the power supply ground to complete the circuit.

Preliminary tests with this setup were successful in igniting the sample in oxygen at low pressures but as the pressure was raised it became more and more difficult to establish the high frequency spark which provides an ionized path for the D.C. welding current to follow. The electrical leadthrough was modified to allow the tungsten electrode to be moved against the sample and then withdrawn to start the arc. This method still did not produce an arc at 900 psig. It did, however, produce a molten puddle on the surface of the sample due to the contact resistance between the electrode and the sample. This molten puddle was not sufficient to produce reliable ignition. The melted spot was in some cases maintained for 10 minutes or more in a pure oxygen atmosphere without causing the sample to burn. A layer of slag, iron oxide, seemed to form over the molten metal and shield it from further oxidation. The gas velocity in the chamber was only 30-40 fps and not sufficient to blow away the molten material exposing new metal to propagate the reaction.

The next attempt to produce ignition was by heating the whole sample rather than a point on the sample. The tungsten electrode was placed in contact with the sample and the current raised to produce resistive heating in the sample. The resistance of the electrical leadthrough turned out to be higher than that of the 1/4" tubing of the sample and its heating limited the safe current to 50 amps. This was insufficient to ignite this size sample.

The sample was changed to a 0.025" carbon steel wire. This sample could be melted in any atmosphere at a current of less than 20 amps. An RCA #SQ2534 photocell was mounted on the window of the reaction cell so that its output in ohms could be calibrated by use of an optical pyrometer to give the temperature of the sample. Only two tests were run with this setup before the project was terminated. The photocell output had not been calibrated against temperature but in oxygen at 900 psig the reading at burnout was 2500 ohms and in nitrogen at the same pressure it was 450 ohms indicating as anticipated a very different burnout temperature.

III. Recommendations

The program from this point would have been to obtain burnout temperatures from the photocell output for several concentrations of oxygen in nitrogen and for several size wires. With this data the burnout temperature could be plotted against oxygen concentration and any discontinuity in this plot would indicate the limiting concentration for that size sample. A geometry effect is anticipated since we know that finely divided iron

such as steel wool will burn in air but a bundle of baling wire will not. The limiting concentration where pipes and other relatively large apparatus will burn could possibly be determined from the data from several sizes of wire by plotting the limiting concentration as obtained above versus 1/d where d is the diameter of the wire. The curve of this plot can be extrapolated to 1/d = 0 to give the oxygen concentration where the surface area to volume ratio of the sample is no longer important. The accuracy of this extrapolation will depend on the scatter in the data.

This program only considered the burning of carbon steel. The same equipment and techniques could provide ignition data for alloy steels and for cast iron to yield more complete design information for oxygen carrying systems.

References

(1) Kitson, F. K.: "Reaction in Reciprocating Nitrogen Recycle Compressor System - Delaware City - January 23, 1968"; APCI memo to M. H. Halsted; February 14, 1968.

(2) Kehat, E.; "Burning of Steel Pipes in a Flowing Oxygen Stream": APCI memo to L. Ball: April 17, 1961.

(3) Kitson, F. K.: "Ignition of Steels in Oxygen Atmospheres": APCI Safety Department Report: August 22, 1962.

(4) Kehat, E.: "Study of the Hazard Level of Hydrocarbon Films in Liquid Oxygen Containing Systems"; APCI memo to C. Sterner: October 31, 1960.

Air Products and Chemicals INC.

COMPANY CONFIDENTIAL

IGNITION LIMITS OF SOME STAINLESS STEELS IN AN OXYGEN ATMOSPHERE

Project 00-7-3480-51.00

Technical Memorandum No. 114

June 24, 1968

B. Bailey

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APPROVALS

Bruce Bailey 6/25/68
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6/29/68
Date

Clyde McKinley 7-1-68
Date

PCI DOCUMENT 2990078R

I. Introduction

A question has come up again about the ignition temperature of various steels in an oxygen containing atmosphere. Earlier this year a study was made for the Safety and Operations Departments of ignition limits of carbon steels in an oxygen-nitrogen atmosphere (1). This program was terminated before any numerical results were obtained as to the ignition temperatures. The new interest in this area came up as a result of a response to a request for quotes for a tonnage compressor which suggested alternate materials of construction. The stainless steels in question here were 304, 309, 316, 410, and 17-4-PH. F. Kitson, in a literature survey on this subject (2), tabulated ignition temperatures of several 300 and 400 series stainless steels, and mentioned two of the above group. The comment made under the "ignition temperature" heading for type 304 was "Ignition occurred within the melting point range". Ignition temperatures were given for type 410 of 2300°F at 50 psia, 2200°F at 300 psia, and 2150°F at 800 psia.

A study was undertaken to determine as much as possible about the ignition points of these alloys in the 2-1/2 days before action had to be taken on the compressor purchase.

II. Experimentation

The test apparatus used was that developed in the earlier Safety Department work. This equipment consists of an electrical power supply and a high pressure reaction cell which has an insulated electrical leadthrough. A sketch of a cross-section of this reaction cell is shown in Figure 1. The 20 amp current transformer used earlier had to be replaced with a 50 amp welding type power supply to accommodate the 1/16" diameter wire of the samples used in these tests. The sample wire was made a part of the circuit by connecting it to the electrical leadthrough. The current of up to 55 amps at 30 volts was passed through the sample while it was housed in the reaction cell pressurized with oxygen from a cylinder. A small purge of oxygen is passed through the cell during the test.

An estimate of the temperature of the sample was made by recording the output of a photocell (RCA #SQ2534) placed on the window of the reaction cell. This photocell changes resistance when exposed to light radiation and the resistance was measured with an ohmmeter. The photocell output was calibrated with temperature using an optical pyrometer (Pyrometer Instrument Co. S.N. 15150) before and after this series of tests.

The test procedure was to attach the sample to the electrical leadthrough and then screwing the leadthrough assembly into the reaction cell. The electrical lead was connected and the cell purged with oxygen. The oxygen pressure was then raised to the desired level by a high pressure regulator on the oxygen cylinder. The power was turned on and the current raised to about 35 amps which heated the sample to around 2000°F. The current was then raised incrementally and the photocell output was recorded as soon as it stabilized at the new level. This was repeated until the sample ignited. The results of these tests are shown in Table I.

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Air Products and Chemicals INC.

BY . DATE . . . . . SHEET NO. OF

SUBJECT . JOB NO. . . . . .

SCHEMATIC CROSS SECTION OF HIGH PRESSURE REACTION CELL

FIGURE 1

TABLE I

IGNITION TEMPERATURES OF SOME STAINLESS STEELS IN °F

Alloy	Pressure 200 PSI	500 PSI	1000 PSI
304	2620	2530	2690
309	2630	*	*
316	2650	*	*
410	2350	*	*
17-4 PH	2550	2520	2600

*Not tested

An observation that was a little surprising occurred during the calibration of the photocell output. During this calibration the test cell was purged and pressurized with nitrogen to prevent ignition of the sample. Both 316 and 304 steels were used in these calibrations. The sample melted at a lower indicated temperature in nitrogen than it burned out in oxygen. Table II illustrates these results.

TABLE II

Alloy	200 PSI N_2	200 PSI O_2	1000 PSI N_2	1000 PSI O_2
304	2590	2620	2610	2690
316	2600	2650	*	*

*Not tested

III. Discussion of Results

The data of Table I seem to indicate that all of these alloys except type 410 are similar in their resistance to ignition. The apparent increase in ignition temperature at the highest pressure was unexpected and does not agree with the very sketchy information on the effect of pressure on ignition temperature that Mr. Kitson was able to locate in the reference cited earlier. This increase was unmistakable in these tests.

The apparent lower melting in nitrogen than in oxygen illustrated in Table II possibly resulted from a layer of higher melting oxides forming on the wire as it was heated in oxygen. This oxide layer then gave some support to the bulk of the material as it began to soften in the melting range. When heated in nitrogen, there was no supporting oxide layer and as soon as the bulk material softened it fell away terminating the test. The difference between ignition and mere melting of the sample may need some further definition but is seemed quite clear in these tests. When the sample melted a section 1/2" to 3/4" long would fall away from near the center of the 5" long sample. When ignition occured, the entire sample was consumed.

The method of temperature calibration with the optical pyrometer is estimated to have an uncertainty of $\pm$ 100°F.

IV. Recommendations

This program was conducted under very severe time limitations in that only 2-1/2 days were available before a decision had to be made on the compressor procurement. Any apparatus modification and the thoroughness of the data taken had to be tailored to this time limit. Only one test was run at each condition so there is no evidence from which to estimate repeatability. More tests should be run not only to fill in the blanks in Table I but also to verify the data which were obtained.

There was no consideration given to an effect on ignition from the size of the wire. We know that a very fine wire in the form of steel wool will burn in air but a heavier wire will not. Will a fine wire have a different ignition temperature? Tests should be run with several sizes of wire in the same alloy to determine if there is a size effect.

The uncertainty in the temperature calibration could be reduced by using thermocouples or some other more sophisticated temperature measuring device.

There is still insufficient information available on ignition temperatures of other steels, even common mild steel or cast iron. Once the apparatus is set up a whole range of materials should be looked at rather than to set up each time to obtain information on one or two materials as required.

Many systems process oxygen-nitrogen mixtures. The effect on ignition temperature of the addition of various amounts of nitrogen to the oxygen should also be investigated.

V. References

1. Bailey, B., "Ignition Limits of Carbon Steel in Oxygen-Nitrogen Atmospheres", APCI Technical Memorandum No. 112, May 8, 1968.

2. Kitson, F. K., "Ignition of Steels in Oxygen Atmospheres", APCI Safety Department Report, August 22, 1962.

Air Products and Chemicals, Inc.

COMPATIBILITY OF MATERIALS WITH LIQUID OXYGEN

by

H. M. Peckham
R. L. Hauser
The Martin Co.

CEC PROCEEDINGS

1958

Advances in Cryogenic Engineering, Volume 4, Page 26-42
21-P, January, 1959.

APCI DOCUMENT
NO. 99000/R9

Air Products and Chemicals INC.

INSTALLATION OF BULK OXYGEN SYSTEMS AT CONSUMER SITES

by

NATIONAL FIRE PROTECTION ASSOC.

1965

NFPA No. 566, 10P
1965

APCI DOCUMENT
NO 29000192

Air Products and Chemicals INC

INSTALLATION OF BULK OXYGEN SYSTEMS

AT CONSUMER SITES

by

National Fire Protection Assoc.

1965

Proposed Admendments
PART II
NFPA No. 566, 3P,
Passed May, 1971 NFPA
No. 50.

APCI DOCUMENT
NO. 99000197

MAINTENANCE AND INSPECTION REQUIREMENTS FOR CUSTOMER BULK GAS SUPPLY SYSTEM

Index to Contents

Par. 1.....General
Par. 2.....Inspection Requirements
Par. 3.....Container Identification
Par. 4.....Record Requirements
Par. 5.....Exhibits

1. GENERAL

Periodic inspection by districts of their customer bulk gas supply systems (cylinder banks, hydril tubes, tube trailer stations, etc.) are essential for trouble-free operation.

2. INSPECTION REQUIREMENTS

Districts will prepare an inspection and maintenance schedule whereby each customer bulk gas supply system/installation shall be inspected for condition as required by IGD form 3097, once every six months.

3. CONTAINER IDENTIFICATION

The container or assembly of containers (tubes or cylinders) shall be provided with a decal or placards identifying the product. The decal or placards must be visible from the loading or charging position.

Cylinders used in storage banks at hospitals shall be painted "Medical Green," but should utilize the standard un-chromed industrial gas service valves. The paint change-over from "Industrial Green" to "Medical Green" should be made during the next bank disassembly for repairs or retesting.

4. RECORD REQUIREMENTS

4.1 The results of the districts' semi-annual inspections shall be recorded on IGD form 3097 (see Exhibit A). It is to be retained at the district for determining subsequent maintenance, and for record purpose.

4.2 The data accumulated by form 3097 will be used as applicable to fill-out the Customer Storage Installation Inspection Summary, form 3242, (See Exhibit B) which shall list all customer storage banks and tube-trailer stations inspected over a three month period.

APCI DOCUMENT NO 9900192

4.2.1 The "Summary" (form 3242) shall be used for either liquid installations as required by Section 4.2.3 and for gaseous installations as required herein. A separate form shall be used for liquid installations and a separate form for gaseous installations.

4.2.2 Identify form use by checking the appropriate block (☐gaseous, or ☐liquid) provided at the upper right corner of the 3242 form. Since form 3242 is to serve as a summary for reporting inspections made over a 3 month period it should list as many inspections as can feasibly be recorded on one sheet. Sheets shall be numbered consecutively 1 of __, 2 of __, etc., in the space provided at the upper right corner on the form.

4.2.3 The "Summary" (form 3242) will be prepared by districts on a quarterly (1st quarter starting January 1st) basis. One copy will be forwarded to the Manager of Engineering, IGD at the Division Office within five (5) days after the termination of a quarterly period. One copy shall be retained by the district for record purposes.

5. EXHIBITS

A facsimile of form 3097 and 3242 required by the above are depicted by Exhibit A and Exhibit B which accompany this procedure.

LCK:kk

Air Products and Chemicals INC
INDUSTRIAL GAS DIVISION

MAINTENANCE AND INSPECTION REPORT

FOR CUSTOMER BULK GAS SUPPLY SYSTEM

Customer Name & Address _____ Date _____

_____ District _____

Person Contacted _____ Inspector _____

_____ Gas: _____

Cylinder Storage or Hydril Tube Bank

Number of cylinders or tubes: _____ Main Bank; _____ Reserve
All fittings, valves and cylinders were soap tested _____ yes; _____ no.
Cylinder Retest Date _____ Main Bank; _____ Reserve
Cylinder or Tube Condition _____ Good; _____ Fair; _____ Poor
Frame and Supports Condition _____ Good _____ Fair; _____ Poor

Tube Trailer

All fittings, valves, and hoses . (✓)_____ yes; _____ no.
Date stamped on hose fittings
_____, _____, _____, _____
For Hydrogen: (✓) Electr[illegible] ystem ____Good; ____Fair; ____Poor

DISTRICT OPERATIONS MANUAL 4.1.3
VOLUME 1 SECTION
EXHIBIT A

Pressure Regulators:

	Model	Set Pressure
In use supply	_____	_____ psig
Reserve Supply .	_____	_____ psig
Houseline	_____	_____ psig
Other	_____	_____ psig

Low Pressure Alarms:

	Alarm Setting
Location - Supply	_____ psig
Reserve	_____ psig
Houseline	_____ psig
Other _____	_____ psig

Paint Condition ..... _____ Good; _____ Fair; _____ Poor
Decal Condition ..... _____ Good; _____ Fair; _____ Poor

Miscellaneous Equipment: (List and Indicate Condition)

List Repairs and Maintenance Performed:

General Remarks: (Indicate Maintenance not performed and when it will be completed)

Safety: List any unsafe conditions. Be specific.

Appropriate signs posted _____ yes; _____ no.

[illegible] 5/71)

Air Products and Chemicals INC.

Industrial Gas Division

CUSTOMER BULK SUPPLY SYSTEM INSPECTION SUMMARY

SHEET ____ OF ____

DISTRICT_____

for

_____CALENDAR QUARTER 19_____

for: GASEOUS SYSTEM ☐
LIQUID SYSTEM ☐

LIQUID TANK (MFGR., UNIT NO. & N. B. NO.) GASEOUS STORAGE: SIZE & NO. OF CONTAINERS	SERVICE	CUSTOMER	LOCATION	INSPECTION DATE	VACUUM	DECALS PLACARDS	PAINT CONDITION

DISTRICT OPERATIONS MANUAL
VOLUME I
SECTION NO. 4.1.3
EXHIBIT B

SUPERVISOR_____

DATE

MAINTENANCE AND INSPECTION REQUIREMENTS

for

BULK LIQUID CUSTOMER INSTALLATIONS

INDEX TO CONTENTS

Par. 1....General
Par. 2....Inspection Requirements
Par. 3....Container Identification
Par. 4....Record Requirements
Par. 5....Exhibits

1. GENERAL

Periodic inspections by districts of their Bulk Liquid Customer Installations are essential for trouble-free operation.

2. INSPECTION REQUIREMENTS

Districts will prepare an inspection and maintenance schedule whereby each customer station will be subject to inspection for condition as required by IGD form 3080, once every six (6) months.

3. CONTAINER IDENTIFICATION

The storage tank shall be provided with a decal identifying the product. The decal must be visible from the loading and unloading position.

4. RECORD REQUIREMENTS

The results of the districts' semi-annual inspections shall be recorded on IGD form #3080 (see Exhibit "A"). It is to be retained at the district for determining subsequent maintenance, and for record purpose.

Data accumulated by the 3080 form will be used (as applicable) to fill out the "Bulk Liquid Customer Installation Inspection Summary" report (see Exhibit "B") which shall list all customer stations inspected over a previous three (3) month period.

The "Summary" (form #3242) will be prepared by districts on a quarterly basis (1st quarter starting January 1st). One (1) copy will be forwarded to the Manager of Engineering, IGD at the division office within five (5) days after termination of quarterly period. One (1) copy shall be retained by the district for record purposes.

5. EXHIBITS

A facsimile of form 3080 and 3242 required by the above are depicted by Exhibit "A" and Exhibit "B" which accompany this procedure.

APCI DOCUMENT NO 99000193

Air Products and Chemicals INC.

INDUSTRIAL GAS DIVISION

BULK LIQUID CUSTOMER INSTALLATION MAINTENANCE AND INSPECTION REPORT

stomer_____ Date_____

ddress_____ District_____

Person Contacted_____ Title_____ Inspector_____

Product_____

Liquid Tank: Capacity_____ Gallons Tank Mfg._____

APCI Serial No._____ National Board No._____

Instrument Readings: Tank Pressure_____ PSIG Houseline Pressure_____ PSIG

Liquid Level_____ In. H_2O

Pressure Control Settings: PCV-1 Tank Pressure_____ PSIG

PCV-2 Houseline Pressure_____ PSIG

PCV-3 Economizer Circuit_____ PSIG

Low Liquid Level Alarm Set at_____ In. H_2O

Tank Vacuum Reading:_____ Microns Note: Tanks with vacuum reading of higher than 200 microns shall be evacuated to a maximum of 50 microns (cold).*

Tank Paint Condition: Good_____ Fair_____ Poor_____ Repainted_____ *

Tank Product Decal Conspicuously Located and in Good Condition_____ Replaced_____ *

Control Cabinet Condition:

	Good	Fair	Poor	Repaired*
Door Hinges and Latching Mechanism- - - - - - -				
Valve Packing (Check for Leaks) - - - - - - - -				
Valve Handwheels (Check for Rusting)- - - - - -				
Regulator Operation - - - - - - - - - - - - - -				
Check relief devices for proper pressure set ting, size, and condition - - - - - - - - -				
Pressure Gages and Liquid Level Gage- -				
Fill Connection (Check Threads and Sup				
Piping (Soap Test for Leaks)- - - -				
Gen'l condition (Interior Cleanli Condition, Brackets and Supp				
Electrical Supply Box Conditi				
Customer Data Label on Insi				

DISTRICT OPERATIONS MANUAL SECTION 4.2.3 EXHIBIT "A" Rev'd. 8/70

Vaporiser: Condition: Good_____ bor_____ Repaired_____ *

Operation: Good_____ Poor_____ Repaired_____ *

Type: Ambient Air_____ No. Units_____ Tot. Cap._____ SCFH

Total Frost 1/4_____ 1/2_____ 3/4_____ Full_____

Steam_____ Mfg._____

Steam Control Station Condition: Good____ Fair____ Poor____ Repaired____ *

Electric_____ Mfg._____

Safety: List any unsafe conditions. Be specific.

_____

_____

Interconnecting Piping: Condition: Good_____ Fair_____ Poor_____ Repaired_____ *

(Soap Check for Leaks, Proper Support, Etc.)

General Area: Indicate Condition of -

	Good	Fair	Poor	Repaired*
Concrete Pad and Foundation - - - -				
Trailer Access Area - - - - - - - -				
Fence - - - - - - - - - - - - - - -				
Area Drainage - - - - - - - - - - -				
Area Lighting - - - - - - - - - - -				

Miscellaneous Equipment: (Gas Reserve Bank, Auxiliary Regulators, External Pressure Buildup Coil, Etc.) List all items not mentioned above and indicate condition and maintenance performed or required. Use back side of this sheet.

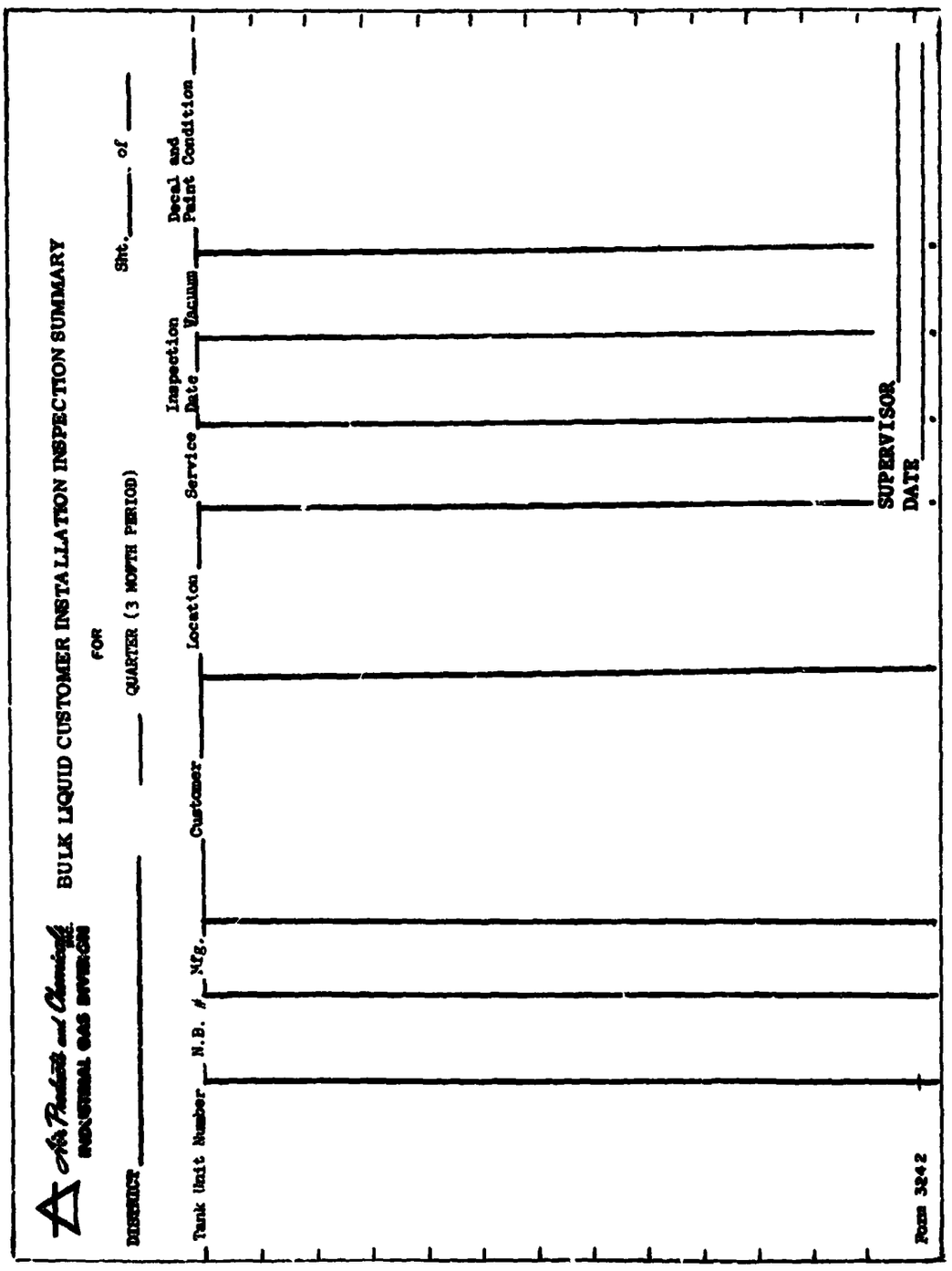
General Remarks: List all discrepancies which were not corrected at time of inspection.

*Detail all repairs and maintenance performed on back side of this sheet.

EXHIBIT B

BULK LIQUID CUSTOMER INSTALLATION INSPECTION SUMMARY

FORM 3242



Form 3242 as depicted here is not actual size.

LOADING AND UNLOADING OPERATIONS

1. PURPOSE

This standard describes the safety regulations for loading and unloading operations performed by licensed drivers.

2. SCOPE

Encompassed are all Air Products and Chemicals, Inc. licensed drivers, and leased and common carrier drivers.

3. GENERAL INFORMATION ON GASES AND CRYOGENIC LIQUIDS

The products transported by Air Products and Chemicals, Inc. and a brief description of these products is listed below:

A. Oxygen - A fire or explosion occurs when oxygen, a flammable material, and a source of ignition are present in the required combination. Any two of the three items cannot result in combustion. In the handling of oxygen it is important to isolate oxygen from flammable materials and from sources of ignition. Many combustible materials such as hydrocarbons (alcohol, coal dust, gasoline, oils, etc.) and other materials may result in an explosion when in contact with liquid oxygen. Ignition can result from an impact or shock, as well as heat.

Oxygen itself will not burn. However, combustion will be more rapid or even explosive in an oxygen enriched atmosphere. If clothing becomes saturated with oxygen, personnel should remain in a well ventilated area for one-half hour while slapping their clothing to aid in dispersion of the oxygen. It is forbidden to smoke or approach open flames or sparks during this one-half hour period, as clothing may ignite and burn violently resulting in severe flesh burns or a fatality. Oxygen saturated clothing should be changed immediately, if possible.

Oxygen concentrations in excess of 25 per cent are hazardous due to increased combustibility and if any doubt exists regarding the oxygen concentration in a working area, the atmosphere should be checked with an analyzer.

Teflon ribbon dope is the only threading compound approved for use in oxygen service due to the flammability of most threading compounds, (570.5.1).

APCI DOCUMENT NO. 99000194

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LOADING AND UNLOADING OPERATIONS

3. GENERAL INFORMATION ON GASES AND CRYOGENIC LIQUIDS (Cont'd)

B. Acetylene, Hydrogen, Propane - These gases and liquids are flammable. In handling these products it is important to prevent an accumulation of vapor or liquid in contact with air (approximately 21 per cent oxygen), and to preclude the source of ignition. Flammable gases in compressed tubes or cylinders may be ignited if rapidly discharged into air due to the heat generated by friction. The inhalation of propane and hydrogen gas is only hazardous in that they are simple asphyxiants. Concentrations above 50 per cent produce symptoms of rapid respiration and concentrations of 75 per cent and above are fatal in a matter of minutes. Acetylene gas is not poisonous if inhaled, although inhalation of excessive concentrations should be avoided due to the anesthetic effect.

C. Nitrogen, Argon - These vapors are non-flammable and the hazard associated with the vapors is asphyxiation as discussed under the previous section.

D. Cryogenic Liquids - It is prohibited to place solids or liquids in cryogenic liquids to watch the effect of the material in the liquid. A warm object placed in a cryogenic liquid will result in the liquid boiling and splashing. Likewise, cryogenic liquids poured into a warm container will result in violent boiling and splashing.

Cryogenic liquids and gases must not be sealed in a transfer hose or piping unless protected by a safety relief device. Vaporization of liquid oxygen results in an expansion ratio of 862 to 1 when warmed to 70°F. At atmospheric pressure, the temperature of liquid oxygen is -297.3°F; liquid nitrogen is -320.5°F; and liquid hydrogen is -423.0°F. Skin contact with these cryogenic temperatures will result in severe burns.

Emergency treatment for burns due to cryogenic liquids is as follows:

(1) Flush the affected area for 15 minutes with clean water to prevent freezing of the flesh.

(2) All burns due to cryogenic liquids, shall be treated by a physician as soon as possible. Do not try to administer first-aid, other than flushing the affected area as noted above.

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LOADING AND UNLOADING OPERATIONS

4. TRUCK AND TRAILER PORTABLE GAS CYLINDERS LOADING AND UNLOADING

The safety precautions to be exercised in the loading and unloading of miscellaneous cargo and portable compressed gas cylinders are as follows:

A. The trailer landing wheels shall be locked in place prior to disengaging the trailer.

B. Wheel chocks are required in place, in addition to locking brakes when parking a tractor and/or trailer.

C. There shall be no smoking, sparks or open flames within a minimum distance of 100 feet of loading or unloading of flammable gases and liquids or within 25 feet of gaseous and liquid oxygen.

D. All cylinders shall be secured to prevent cylinders from falling over.

E. The driver shall check the side and rear gates on the truck to insure the gates are in a locked position.

5. CRYOGENIC LIQUID TRAILERS

The safety precautions to be exercised in the loading and unloading of cryogenic trailers are listed below:

A. Vehicles shall not enter area containing an oxygen enriched atmosphere or a flammable gas atmosphere. Also, vehicle engines shall not be started in any atmosphere suspected of containing a high oxygen concentration or a flammable gas. A vehicle shall not enter a loading area until permission has been granted by the personnel responsible for the loading operation. Permission will be given after ascertaining that the immediate area is not hazardous due to venting trailers. Similarly, a vehicle engine shall not be started in preparation to move a trailer until permission has been granted by the personnel responsible for loading operation. At no time is the engine to be started or allowed to run during loading or unloading of the trailer.

B. Wheel chocks are required in place, in addition to locking brakes when parking a trailer.

C. The motor vehicle shall not be disengaged or engaged to a trailer when a transfer hose is connected to the trailer.

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LOADING AND UNLOADING OPERATIONS

5. CRYOGENIC LIQUID TRAILERS (Cont'd)

D. Oxygen loading and unloading is prohibited in the vicinity of simultaneous loading or unloading of gaseous or liquid fuel.

E. There shall be no smoking, sparks, or open flames within a minimum distance of 100 feet of loading or unloading of a flammable liquid or LOX. The tractor ignition switch and light circuit must be turned off during loading or unloading operations.

F. A driver shall not go into a loading area which he considers to be unsafe. He shall immediately contact his supervisor and explain the unsafe condition in detail.

G. On hydrogen trailers the electric ground wire shall be attached to the trailer prior to connecting the transfer hose for loading or unloading operations.

H. Loading and unloading operations shall not commence or continue if a leak develops or if any condition exists which would be hazardous to the transfer operation. It is prohibited to hammer a transfer hose connection while transfer is being made.

I. Steam or hot water should be used to thaw frozen piping or equipment. Frozen valves should be thawed by directing water on the valve bonnet and extension below the packing nut. Never direct water on the packing nut or packing area.

J. Personnel loading and unloading liquid tanks shall report to their supervisor any foreign deposits observed in transfer hoses or in fill and drain connections.

K. Prior to disconnecting a liquid transfer line, the line shall be drained; never assume a line has been drained by another person.

L. In the event of a liquid spill while transferring liquid, the trailer shall be checked in detail for damage, such as frozen tires, fractured metal, etc., prior to moving the trailer.

M. The transfer, drain and fill lines should be capped at all times when not in use.

Air Products and Chemicals, Inc.

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LOADING AND UNLOADING OPERATIONS

5. CRYOGENIC LIQUID TRAILERS (Cont'd)

N. Prior to starting the tractor engine, the driver shall make a complete circuit of the trailer to insure the transfer line is disconnected, electric grounds removed, wheel chocks removed and stored in their proper location, and compartment doors closed and latched.

NOTE: Failure to disconnect a transfer hose prior to moving a trailer shall be considered a serious infraction of safety.

O. The following personnel protection should be worn during liquid loading or unloading:

(1) Insulating gloves (asbestos, rubber, leather);

(2) Chemical goggles;

(3) During oxygen loading, clothing shall be free of grease and oil.

6. TUBE TRAILER

The safety precautions to be exercised in the filling and unloading of tube trailers are listed below:

A. The trailer landing wheels shall be locked in place prior to disengaging the trailer. The tractor shall be disengaged and removed from the area after parking a hydrogen trailer.

B. Wheel chocks are required in place, in addition to locking brakes when parking a tractor and/or trailer.

C. The motor vehicle shall not be disengaged or engaged to a trailer when a transfer hose is connected to the trailer.

D. Oxygen loading and unloading is prohibited in the vicinity of simultaneous loading or unloading of gaseous or liquid fuel.

E. There shall be no smoking, sparks, or open flames within a minimum distance of 100 feet of loading or unloading of a flammable gas or within 25 feet of loading or unloading of oxygen.

Air Products and Chemicals

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LOADING AND UNLOADING OPERATIONS

TUBE TRAILERS (Cont'd)

F. A driver shall not go into a loading area which he considers to be unsafe. He shall immediately contact his supervisor and explain the unsafe condition in detail.

G. On hydrogen trailers, the electric grounding wire must be secured to the trailer prior to commencing loading or unloading operations.

H. Loading and unloading operations shall not commence or continue if a leak develops or if any condition exists which would be hazardous to the transfer operation.

I. Prior to disconnecting the transfer hose, the pressure should be relieved by opening the vent valve.

J. The transfer, drain and fill lines should be capped at all times when not in use.

K. Prior to starting the tractor engine, the driver shall make a complete circuit of the trailer to insure the transfer line is disconnected, electric grounds removed, wheel chocks removed and stored in their proper location, and compartment doors closed and latched.

NOTE: Failure to disconnect a transfer hose prior to moving a vehicle shall be considered a serious infraction of safety rules.

L. The following personnel protection should be worn during tube trailer loading and unloading:

(1) Monogoggles and gloves will be worn when operating valves, when making or breaking transfer hose connections, and when standing in front of a tank or tanker control cabinet during product transfer. Safety glasses and face shields may be considered a suitable substitute for the monogoggles.

(2) Hard hats will be worn in plant areas, Air Products Facilities and customer locations, where required by local plant safety rules.

(3) During oxygen loading, clothing shall be free of grease and oil.

Air Products and Chemicals

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Air Products and Chemicals INC.

SAFETY RELIEF DEVICE STANDARDS

by

Compressed Gas Assoc.

Part I

Cylinders for Compressed Gases, CGA, Pamphlet 341, 4.1.3 2P, June, 1971.

APCI DOCUMENT #9000195

Air Products and Chemicals INC

SAFETY RELIEF DEVICE STANDARDS

PART I

by

Compressed Gas Assoc.

CGA-Pamphlet S-1.1,
20P, 1969

APCI DOCUMENT
0_9900196

FIRE EXTINGUISHMENT

1. PURPOSE

This standard describes the policy and procedure for fire extinguishment.

2. SCOPE

This standard encompasses all vehicles operated by Air Products and Chemicals, Inc.

3. POLICY AND PROCEDURE

The environment under which a fire may originate is difficult to anticipate. Each situation must be met with clear thinking, resulting in quick action to prevent injury to the public, to prevent equipment and property damage, and to retard propagation of the fire. The material presented below is offered as a guide to aid in determining the proper course of action.

A. Fires Involving Trucks and Truck-tractors

The truck driver, upon discovering a fire, should immediately pull the motor vehicle to the side of the road into the least hazardous area. When on the highway, it is advisable to turn off on a side road or lane, if available. The ignition should be turned off and the fire extinguisher removed from the cab.

(1) If the fire originates in the vicinity of the engine, the following action should be taken:

a. Attempt to extinguish the fire with the extinguisher. If the fire is not extinguished when the extinguisher is depleted, attempt to smother the fire by throwing sand or dirt on the burning area.

b. Stop a passing vehicle with a minimum interruption of the fire fighting and request someone to summon aid from the nearest fire and police department.

c. Do not leave the scene until the fire has been completely extinguished and the burning material cooled to a temperature which would preclude the possibility of reignition.

d. The driver should then report the fire, extent of damage, and request instructions from his supervisor.

APCI DOCUMENT NO. 99000192

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FIRE EXTINGUISHMENT

POLICY AND PROCEDURE (Cont'd)

A. Fires Involving Trucks and Truck-tractors (Cont'd)

(2) If the fire originates on a wheel (brake lining or hydraulic brake system) without involving the tire, proceed as in Section 1.

(3) If the fire originates on a tire, the following action should be taken:

a. Attempt to extinguish the fire with water, if available, or with the extinguisher until depleted, then with sand or dirt.

b. Stop a passing vehicle with a minimum interruption of the fire fighting and request someone to summon aid from the local fire and police departments.

c. Do not leave the scene until the temperature of the tire is sufficiently lowered to preclude the possibility of reignition of the tire. Tires may reignite as much as 20 to 30 minutes after the initial fire has been extinguished, and under test have reignited as many as 10 to 12 times.

d. The driver should then report the fire, the extent of damage, and request instructions from his supervisor.

NOTE: Tire fires are a result of excessively high temperatures. Adequate precautions will reduce the number of tire fires. These high temperatures usually result from:

/1/ Overloading

/2/ Under inflation

/3/ High speed

/4/ High ambient air and road temperature

/5/ Chafing and rubbing of dual tires when soft or flat.

Air Products and Chemicals, Inc.

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FIRE EXTINGUISHMENT

3. POLICY AND PROCEDURE (Con't)

B. Fires Involving Hydrogen Cryogenic Tankers or Tube Trailers

A hydrogen fire propagates very rapidly and for this reason is difficult to extinguish. If liquid hydrogen spills on the ground from a tank, the liquid rapidly vaporizes, and being colder than ambient air, will produce a vapor cloud plume. When a source of ignition is present, the flame will rapidly flash back to the source and consume the hydrogen in a very short time. If the hydrogen is not confined, an explosion will probably not take place. Hydrogen gas venting very rapidly or impinging on a metal surface may ignite due to the heat of friction. An example of this might be a rupture in a high pressure fill line which could ignite from the heat of friction. Caution must be exercised in the vicinity of a suspected hydrogen fire due to the invisible nature of the flame. If a foreign material is involved in the fire, the flame will be visible, but, if hydrogen is the only source of fuel, the fire can only be detected by heat waves.

The following actions should be taken in the event of a hydrogen fire:

(1) Attempt to shut off the supply of hydrogen. In the event a shut-off valve is inaccessible due to heat, fog nozzles may be used when local fire equipment is available to afford personnel protection in approaching the valve.

(2) Restrict the area for a minimum distance of 600 feet in all directions, and dispatch someone to summon the aid of the local fire and police department.

(3) Request the local fire department to contain the fire by playing water on nearby flammable material and on the tank or tube to lower the temperature and prevent rupture of the vessel. The vessel head is the most likely location for rupture to occur, and therefore, fire fighters should be positioned at a safe distance on the side of the trailer, never directly to the rear of the trailer.

(4) If the fire is due to an extremely small leak, it may be possible to snuff out the fire with the purge nitrogen cylinder supplied on some trailers. If the fire is large, allow the fire to burn out. Hydrogen vapors, if dispersed by water streams, may concentrate in a more hazardous location and reignition may take place.

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FIRE EXTINGUISHMENT

. POLICY AND PROCEDURE (Cont'd)

B. Fires Involving Hydrogen Cryogenic Tankers (Cont'd)

(5) Do not leave the scene until a positive check has revealed that the hydrogen source is completely depleted or shut off and the tank temperature is sufficiently cooled down to prevent further venting and reignition.

(6) The driver should then report the fire, the extent of damage, and request instructions from his supervisor.

C. Fires Involving Oxygen Cryogenic Tankers or Tube Trailers

A fire involving high oxygen concentrations will result in flames of much greater intensity than in air. The procedure in fighting the fire would be the same as standard fire fighting techniques once the source of oxygen is shut off. The course of action to be taken is as follows:

(1) Attempt to shut off the supply of oxygen. In the event a shut-off valve is inaccessible due to heat, fog nozzles may be used when local fire equipment is available to afford personnel protection in approaching the valve.

(2) Restrict the area for a minimum distance of 600 feet and dispatch someone to summon the aid of the local fire and police departments.

(3) The fire should be extinguished as rapidly as possible with water streams. Oxygen will not burn; therefore, the burning material should be cooled below its ignition temperature to extinguish the fire. The increase in tank or tube temperature may result in a rupture of the vessel. The vessel head is the most likely location for rupture to occur, and therefore, fire fighters should be positioned at a safe distance on the side of the trailer; never directly to the rear of the trailer.

(4) Do not leave the scene until a positive check has determined that the burning material is sufficiently cooled to prevent reignition.

(5) The driver should then report the fire, the extent of damage, and request instructions from his supervisor.

Air Products and Chemicals

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FIRE EXTINGUISHMENT

3. POLICY AND PROCEDURE (Cont'd)

D. Fire Extinguishers

An approved fire extinguisher shall be provided on each motor vehicle. The extinguisher shall be maintained in a full condition with the seal intact and mounted in an appropriate hanger. If the extinguisher is activated, a replacement shall be provided until the original extinguisher is completely charged.

E. Each tractor and pumper shall carry one 5 pound dry chemical extinguisher mounted inside the cab and one 30 pound dry chemical extinguisher mounted on the outside of the cab.

F. Each straight truck shall carry one 5 pound dry chemical extinguisher.

G. Each liquid hydrogen tanker shall carry a minimum of one 20 pound dry chemical extinguisher.

Air Products and Chemicals

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Date
5/15/69

Air Products and Chemicals INC

EQUIPMENT CLEANED FOR OXYGEN SERVICE

by

Compressed Gas Assoc.

1959

CGA Pamphlet G-4.1
21P, March 1959

REF: DOCUMENT NO 9200198

E-4

HAZARD LEVEL OF HYDROCARBON FILMS IN SYSTEMS CONTAINING LIQUID AND GASEOUS OXYGEN*

E. Kehat

Air Products and Chemicals, Inc.
Allentown, Pennsylvania

Introduction

The object of this work was to determine realistic standards of cleanliness in systems containing liquid and gaseous oxygen. An arbitrary figure of 4 mg/ft^2 [1] had been set by examination of systems that had caused no trouble in the past. It was felt that this figure was too low and that experimental determination of the safe level should be made to set such standards.

Previous workers had tested high surface concentrations of oils, which were found to be highly explosive in liquid or gaseous oxygen and in high-pressure air. Palmer [2] reported some work performed by Loison in 1952. A nominal 1-in. pipe, approximately 250 ft long, with an oil film of 20,000 mg/ft^2 (about 0.3 mm thick) and with air at a pressure of 100 psig was used. Upon ignition, a pressure wave was generated and the walls of the pipe were ruptured in a number of places.

Basyrov and Mikhedov [3] studied the detonation limits of some Russian lubricating oils solidified and dispersed in liquid oxygen at concentrations of 7.5 to 21% oil. For one type of spindle oil in a mixture of 15% oil in liquid oxygen, the detonation ability was similar to that of TNT.

Some unsystematic work had been done here in 1956 and 1957 [4] on ignition of a variety of lubricants in air, oxygen, and liquid oxygen. The amounts of oil were substantial and powerful detonators were used. The sound of the detonation and a study of the surviving parts of the equipment indicated that the oil ignited in all tests. No quantitative data of the oil-film concentrations were taken. Based on these meager past experiments, the range of concentrations of interest for this study was taken as 4 to 20,000 mg/ft^2.

Experimental

A n-hexadecane film was applied evenly to the surface of a clean section of pipe. The boiling temperature and the molecular weight of n-hexadecane are in

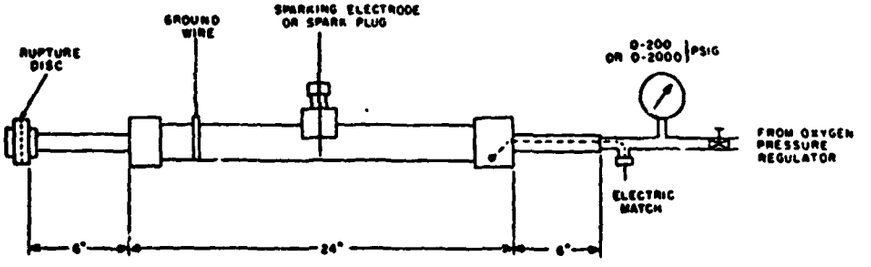


Fig. 1. Ignition apparatus using gaseous oxygen.

*This study was supported by the U.S. Air Force under Contract No. AF 33(616)-6730.

Advances in Cryogenic Engineering, Vol I,
Timmerhaus, K.D., Editor, Plenum Press, N.Y. (1962)

AFCI DOCUMENT
NO 92000199

HAZARD LEVEL OF HYDROCARBON FILMS IN OXYGEN SYSTEMS

W. Leonard Ball
Air Products and Chemicals
Allentown, Pennsylvania

1962

"How clean is clean" is an expression frequently heard when the discussion concerns cleaning an oxygen handling system. Present knowledge of oxygen-fuel systems indicates there is a certain level of contamination that can be safely tolerated. This level will be affected by such factors as type of contaminant, pressure and temperature.

The question: "What is this tolerable limit and exactly what effect do these various factors have?"

Commercial practice is not satisfactory for the systems required for liquid propellant rockets. After an analysis of the degree of cleanliness of successful systems, a level of four milligrams of hydrocarbons per square foot was established. This degree of cleanliness produces acceptable systems—but is costly in both time and money. Often five or six steps of washing, flushing, and purging are required.

The investigation

Under an Air Force contract, Air Products and Chemicals Research and Development Department has investigated the possibility of ignition of a hydrocarbon film on the wall of piping for oxygen service for the purpose of better defining the safe level of contamination. While this work is not yet complete, the results to date have been informative:

For these tests, n-hexadecane was used as the hydrocarbon contaminant as its boiling temperature and molecular weight are in the range of common lubricants. The experimental equipment consisted of a schedule 40 stainless steel pipe section two feet long, one inch nominal diameter, with a six inch long section of one-half inch stainless steel at each end. For the runs involving gaseous oxygen, rupture discs made from modified one-half inch unions and brass foil were installed on one end of the section.

The hydrocarbon film was applied to the inside surface from a solution of n-hexadecane in carbon tetrachloride which was evaporated in a hot water bath while rotating the pipe section to achieve uniformity of the hydrocarbon film. The quantity of hydrocarbon deposited on the surface was controlled by the quantity and concentration of the feed solution. After application of the film, the pipe section was cooled to room temperature and the igniter and oxygen line connected. After purging the pipe section for five minutes to insure removal of the last traces of the solvent vapors, the rupture disc assembly was tightened, the oxygen pressure raised to the desired setting and ignition applied.

Blank runs

The pipe assembly was then disassembled and the unburned hexadecane dissolved in two batches of fresh carbon tetrachloride. This solvent was then combined and concentrated by evaporating most of the solvent. After measuring the quantity of the concentrate, the concentration of n-hexadecane was determined by a Beckman IR-4 infrared analyzer. For blank runs the same procedure was followed except ignition was not applied and pressure was held at 50 psig for five minutes.

Liquid oxygen

For runs involving liquid oxygen the one-half inch end sections were removed after the film was applied and one end of the one inch diameter section capped. Rather than pour the liquid oxygen in, the experimental section was immersed in a vertical position in liquid nitrogen and gaseous oxygen condensed until the section was about 80 per cent full. Following ig-

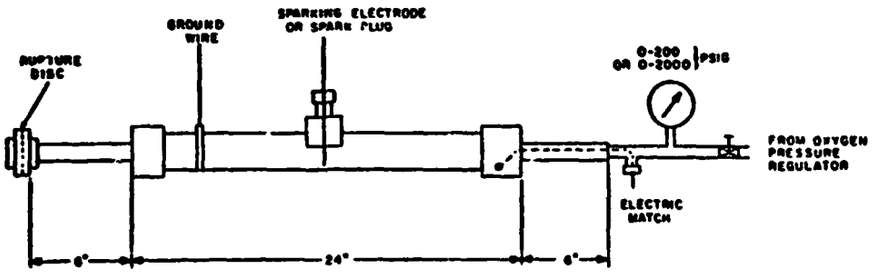


Figure 1. Ignition apparatus using gaseous oxygen.

AIChE, Safety in Air and Ammonia Plants, Vol. 4, pp. 16-20 (1962)

APCI DOCUMENT NO. 99 000 200

THE RELATIONSHIP OF THE CHEMICAL STRUCTURE OF CUTTING OILS TO THEIR OXYGEN COMPATIBILITY

R. A. Walde
Air Products and Chemicals, Inc.
Allentown, Penn.

A considerable amount of work has been done in the past studying the compatible concentration of various oils with high pressure oxygen. This work has employed numerous types of test devices and has examined lubricating, compressor, and cutting oils. Compatible concentration has normally been described as the concentration of oil as a film below which no reaction takes place. Depending upon the type of oil and the test used, results ranging from a few mg./sq. ft. up to 500 mg./sq. ft. have been reported as being the upper limit of the safe region. In most of these studies little attention was given to the effect of chemical structure on the compatibility of a particular series of oils.

It is the objective here to demonstrate the importance of considering chemical nature as well as concentration when establishing safe concentration levels for a particular series of oils. For this study one has chosen to examine cutting oils which are commonly used in the manufacture of machine parts such as valves. The oils were classified according to their chemical structure by infrared analysis and their compatible concentration determined in the presence of pure gaseous oxygen at 1,500 lb./sq. in. gauge.

Test system

The basic test system used was originally developed by E. Kehat of Air Products and Chemicals and is described in a paper that was presented at the Cryogenic Engineering Conference in August, 1961. Modifications have been made in the test procedure that give improved results. Figure 1 shows a schematic diagram of the test system. The main body is composed of a 2-ft. piece of schedule 40 stainless steel pipe with a rupture disk at one end, a gas feed orifice at the other end, and a wire igniter placed in the center. The effective surface area is 0.689 sq. ft.

The oil films are placed on the surface of the bomb by adding a particular volume of a methylene chloride solution of the oil to the bomb and evaporating the solvent while rotating in a hot water bath. The concentration in mg./sq. ft. is determined by the concentration of oil in the methylene chloride solution and the volume of it added to the bomb. It is important during evaporation to be sure that all of the solvent is completely removed since small quantities of residual solvent can have a considerable effect on the results obtained. Methylene chloride is a very good solvent for this purpose because of its volatility and low reactivity with oxygen.

Effect of oil film

A significant test variable observed in this study was the effect that an oil film placed on the igniter wire during evaporation had on the compatible concentration. Table 1 gives some comparative results of nonreactive concentrations determined for hexadecane and cutting oil blends when the igniter wire was in place during evaporation of the solvent and when it was put in place after evaporation of the solvent. As can be seen, the nonreactive concentrations determined are much lower when the igniter wire is free of any oil film than when it is coated with oil. These lower concentrations are possibly due to ablative cooling of the igniter wire by the oil film which results in a lowering of the initiation energy peak. In order to obtain meaningful results which can be uniformly correlated, the ignition system should not be contaminated with the oil. Therefore, in this study the ignition system was put in place after evaporation of the solvent had been completed. After evaporation of the solvent and putting the ignition system in place, the bomb was purged with oxygen, pressurized to 1,500 lb./sq. in. gauge, and the wire ignited. The ignition system used was composed of a 1.75-in. piece of 11.5 mil Nichrome wire having a resistance of

TABLE 1. EFFECT OF OIL COATING ON IGNITER WIRE ON COMPATIBLE OIL CONCENTRATION.

Oil	Compatible concentrations, mg./sq. ft.	
	Igniter free of oil	Igniter coated with oil
Hexadecane	150	400
Blend #2	50*	150
Blend #1	300	400

*Reaction still occurs.

AIChE, Safety in Air and Ammonia Plants, Vol. I
pp. 21-23 (1965)

APCI DOCUMENT NO. 99000201

SAFETY CONTROL PROCEDURE - TAG OUT

This Procedure is Identical with Section 626.3.3 Safety Standards

I. PURPOSE

To establish a standard procedure that is applicable in every operating plant or manufacturing facility, and which encompasses all phases of the company's operations pertaining to tag out procedures for the positive isolation of a circuit, valve or other system where strict safety measures are required for the protection of personnel and equipment.

II. RESPONSIBILITY

The Plant Manager, Maintenance Superintendent, and operating personnel are responsible for compliance with the provisions of the procedure as applicable to equipment or duties with which they are concerned.

III. PROCEDURE

A. The person having responsibility for the equipment and the work to be done must determine the hazard both to personnel and equipment by review of drawings, flowsheets, specifications, experience or other means, and by a physical inspection of the work site. He can then determine the valves to be closed (or opened as in vents), the electric switches to be opened, etc., to provide a safe working environment.

B. After the valves, switches, etc., have been properly positioned, danger tags shall be filled out and affixed to the equipment. The tear-off portion shall be given to the person(s) who will actually do the work.

C. The valve, switch, etc. shall not be operated nor the danger tag removed until the tear-off portion and the tag are reunited.

D. An up-to-date log of all danger tags and their disposition shall be kept by the person having responsibility for their issuance.

E. After repairs are completed, the man in charge of the repair work shall have a checklist of men on the job and see that all men are properly instructed, counted, and in the clear before the last danger tag is removed.

F. When the work has been completed and all workers are counted and in the clear, the tear-off portion of the tag shall be returned to the person responsible for the issuance of danger tags. When the tear-off portion has been reunited with the tag, the tag may be removed and the system activated.

APCI DOCUMENT NO 99000202

SAFETY CONTROL PROCEDURE - TAG OUT

G. Should the job progress into the next shift, the tear-off position of the tag will be passed on to the workman doing the work on the next shift. The log is also turned over to the responsible party on the next shift.

H. If any man protected by a danger tag issued to a group should desire, he may also attach his personal danger tag when he starts work on the job and remove it when he leaves.

I. These tags (form 2027) are stocked and may be ordered from Stationery Stores.

Note: This procedure is also summarized in your pocket size Operations Safety Manual, Pages 25 and 26.

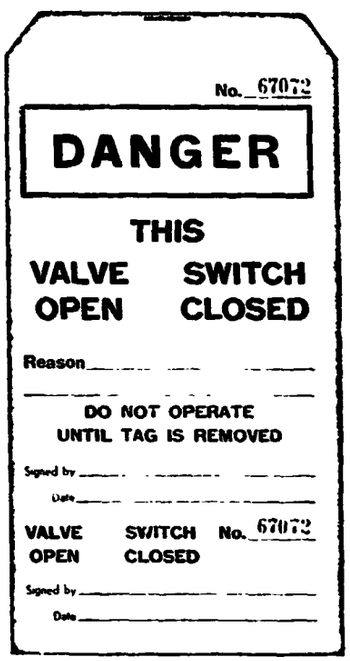
IV. RELATED PROCEDURES

1.02, Safety Control Procedure - Construction, Start-up and Operations.
1.04, Safety Control Procedure - Safety Work Permit

V. RELATED FORMS

2027, DANGER Tag (Exhibit A).

Section 1.03
Exhibit A
2/15/67



(front)



(back)

Color: International Orange
Form No.: 2027
Material Code No.: 4-847-51-1001

SAFETY CONTROL PROCEDURE - SAFETY WORK PERMIT

This Procedure is Identical with Section 626.3.5 Safety Standards

I. PURPOSE

To establish a standard procedure for the use of Safety Work Permits to achieve constant, close control of operations and maintenance work on or near potentially dangerous process equipment, thereby minimizing the hazard to personnel and to the equipment.

II. RESPONSIBILITY

A. Plant Managers shall be responsible for the issuing and control of Safety Work Permits.

B. Plant Managers may delegate the actual work of issuing and controlling the permits to the Maintenance Superintendent or to the Shift Supervisor, as conditions indicate.

III. PROCEDURE

A. Scope

Use this procedure whenever maintenance or repair work is to be done on or near process equipment and any one of the following conditions will be encountered:

1. Outside contractor personnel will be involved.

2. Burning, welding, soldering or other hot work on or near cold boxes, storage tanks, or transfer systems containg liquid or gaseous oxygen or fuel gases.

3. Entry of a tank, vessel, column, or cold box.

4. Opening of a process line or vessel.

5. Whenever safety tagging of electrical, mechanical, or process equipment is required.

6. Creation of a potential hazard in an operating area.

7. Potential hazardous exposure of personnel to process streams or equipment through the normal or emergency operation of process valves, controls, etc.

APCI DOCUMENT NO. 9900203

SAFETY CONTROL PROCEDURE - SAFETY WORK PERMIT

B. No work will be done if any of the conditions noted in A, above under Scope exist until a Safety Work Permit has been issued.

C. Safety Work Permits may be issued to cover an area such as would be required for expansion of existing facilities and additions of major pieces of equipment, as well as for work on individual pieces of equipment.

D. The person issuing the permit will survey the area where the work is to be done and the equipment that will be involved to determine that the work can be done safely. It is mandatory therefore, that he be completely familiar with the details of the process equipment, the process flow and work that may be in progress or contemplated in adjacent areas.

E. If Danger tags are required to isolate certain equipment or systems, the tag numbers will be recorded on the Safety Work Permit and the permit will not be issued until the tags are in place. It is the responsibility of the originator to insure that the equipment, system or area has been prepared properly for the work to be performed.

F. Any special precautions or instructions necessary to perform the job safely will be noted on the Permit. If special safety equipment or clothing is required, it shall be specifically noted.

G. The Safety Work Permit will be made out in duplicate and a log made out of its existence and disposition.

H. The original copy will be given to the man or supervisor of the crew, who will be doing the work. The copy will be kept by the originator.

I. If the work continues beyond one shift, the original copy will be passed on to the man or supervisor who is to continue the work. When the work is completed this will be noted on the permit and the permit returned to the originator.

J. The Safety Work Permit shall be considered to be active until it has been physically returned to the originator by the person responsible for the accomplishment of the work.

K. Once a Safety Work Permit has been issued, the originator shall periodically inspect the work site and the work in progress to insure that all special precautions and instructions are being complied with and that there are no hazards to personnel or to equipment.

Note: This procedure is also outlined in the pocket size Operations Safety Manual on pages 22, 23 and 24.

SAFETY CONTROL PROCEDURE - SAFETY WORK PERMIT

IV. RELATED PROCEDURES

1.02, Safety Control Procedure - Construction, Start-up and Operations.

1.03, Safety Control Procedure - Tag Out

V. RELATED FORMS

2026, Safety Work Permit (Exhibit A).

Section 1.04
Exhibit A
2/16/67

Date.....
Time.....
M.O. No.....

AIR PRODUCTS AND CHEMICALS, INC.
SAFETY WORK PERMIT

№ 1427

This authorizes.....to do the following work:

.....

.....

Special precautions to be exercised by personnel performing work: .....

.....

.....

TYPE OF WORK		SAFETY PREPARATION FOR WORK		STATUS	
HOT WORK: BURN - WELD - SOLDER	☐	TEST FOR: EXPLOSIVE	☐	PERMIT EXPIRES:	
ENTRY: VESSEL - COLUMN - ENCLOSURES	☐	O_2	☐	TIME: ..... DATE:.....	
ALTERATIONS - REPAIRS - OPENING EQUIP	☐	O_2 DEFICIENCY	☐	WORK STATUS:	
DRILLING - GRINDING - CHIPPING	☐	TAG OUT: ELECTRIC SWITCHES	☐	COMPLETE	☐
VEHICLES: ENTRY OF OPERATING AREA	☐	VALVES	☐	INCOMPLETE	☐
ELECTRICAL:	☐	PUMPS	☐	DETERMINED BY: ..... (Maint. or Shift Supv.)	
OTHER.		TAG NO.			
		INSTALL BLANKS OR BLINDS	☐		
		BLEED PRESSURE	☐		
		OTHER			
ISSUED BY: FORM 2026		FIELD CHECKED BY:		TIME: ..... DATE:	

CODED VESSEL REPAIRS

I. PURPOSE

To establish a standard procedure for field repairs, alterations, and additions to pressure vessels constructed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code.

II. RESPONSIBILITY

The Plant Manager, or an individual authorized by the Plant Manager for supervision of repairs, shall be responsible for the execution, test, and acceptance of the repair, alteration, or addition.

The repair, alteration, or addition must receive final approval from the Maryland Casualty Company inspector for the state in which the vessel is located. Before the work is begun, the Plant Manager shall call the inspector. The proposal for the method of repair shall be discussed by them at the vessel site before any work is done. In emergencies, a repair method may be agreed upon by telephone, but the insurance inspector will still have to give final approval before the vessel is put back in service.

At some APCI facilities, the vessels are not insured, particularly where there are no code requirements. However, it is our policy to maintain the code status on vessels, and the procedure given below shall be followed. In such cases, the insurance inspector will still be consulted, but APCI may have to reimburse Maryland Casualty for his service.

Rev.

Some states or localities may have some additional standards of inspection, repair, or reporting, and a state or municipal inspector may also be required to witness the work. The Plant Manager shall discuss state requirements with the insurance inspector, who will be familiar with the requirements of his territory.

A copy of the inspection contract between APCI and the Maryland Casualty Company is shown in Attachment 1 of this procedure.

III. PROCEDURE

A. Obtain Manufacturers' Data Report for unfired pressure Vessels, forms U-1 or U-1A, (Exhibits A and B) and prints before the repair is made, so there is no doubt about the correct materials and method of construction. If there are still

APCI DOCUMENT NO. 99000a204

CODED VESSEL REPAIRS

questions or problems concerning the method of repair, or if the inspector is not available, contact the Operations Safety-Service Manager or the Operations Manager of Maintenance and Mechanical Engineering.

B. Perform all repairs, alterations, or additions according to the rules in Section VIII of the ASME Boiler and Pressure Vessel Code and Chapter VI of the National Board Inspection Code. When welding is a part of the work, each welder and welding operator who actually performs the welding shall have proof of qualification in accordance with Section IX of the ASME Code and with the procedures used in the repair. Proof of such qualification must be presented also by outside contractors who do this work.

C. Upon completion of the work, test the vessel as follows:

1. Radiography

a. When the vessel has been x-rayed 100 percent, the repair, alteration, or addition must also be x-rayed 100 percent if it includes a main weld seam (circumferential or longitudinal).

b. When the vessel has been spot x-rayed, the repair, alteration, or addition must be x-rayed if it includes a main weld seam.

NOTE

If the vessel has been 100 percent x-rayed, the letters XR will be stamped on the left side; the U-1 form will also indicate a 100 percent x-ray. Check U-1 or U-1A forms to determine whether there was a spot x-ray.

2. Dye Penetrant

When the repair or alteration is a weld around an opening or an attachment weld having a throat thickness of greater than 1/4 inch, inspect the weld 100 percent with dye penetrant.

CODED VESSEL REPAIRS

3. Stress Relief

When the letters SR or PSR appear on the vessel nameplate, the vessel has been stress relieved or partially stress relieved. For such vessels, the code inspector should decide whether the proposed repair, alteration, or addition should be stress relieved.

4. Pressure Test

The Plant Manager shall decide whether a hydrostatic or pneumatic test should be performed.

a. Hydrostatic - Use Quality Control Standard QCL-117A (Attachment 2) as a guide in performing a hydrostatic test.

b. Pneumatic - use Quality Control Standard QCL-105A (Attachment 3) as a guide in performing a pneumatic test.

D. When the work has been completed to the satisfaction of the insurance inspector, Form 6601, Record of Repair and/or Alteration (See Exhibit C) shall be completed by the welder and the inspector. Blank forms may be obtained from the Operations Safety-Service Manager. Copies shall be distributed to:

1. The code inspector
2. Plant file
3. Operations Safety-Service Manager
4. APCI Manager of Quality Control in the Allentown office (2 copies).

E. For any further assistance, contact the Operations Safety-Service Manager or the Operations Manager of Maintenance and Mechanical Engineering.

IV. RELATED PROCEDURES

ASME Boiler and Pressure Vessel Code, Sections VIII and IX

National Board Inspection Code, Chapter VI.

CODED VESSEL REPAIRS

Maryland Casualty Company Field Inspection Contract (Attachment 1)

QCL-117A, Hydrostatic Testing - General (Attachment 2)

QCL-105A, Pneumatic Testing - General (Attachment 3)

V. RELATED FORMS

U-1, Manufacturers' Data Report for Unfired Pressure Vessels (Exhibit A)

U-1A, Manufacturers' Data Report for Unfired Pressure Vessels (Exhibit B)

6601, Record of Repair and/or Alteration (Exhibit C)

6.09
ATTACHMENT I

FIELD INSPECTION CONTRACT

(PART - TIME)

Maryland Casualty Company of Baltimore, Maryland (hereinafter called Maryland) hereby agrees with

AIR PRODUCTS AND CHEMICALS, INCORPORATED
ALLENTOWN, PENNSYLVANIA

(hereinafter called Contractor) with respect to inspection services as follows:

1. Maryland will provide a field inspector for service at the generating facilities of Contractor's properties described in endorsement no. 1 of Maryland Boiler and Machinery policy no. R-0041000 during the regular working hours of each regular working day, as required. For the purposes of this Agreement: (1) "Regular working hours" is intended to exclude the hours prior to 7:00 A.M. and subsequent to 5:00 P.M.; (2) "Regular working day" is intended to exclude Sundays and holidays and shall not exceed eight hours in any twenty-four. Any overtime not within the above stipulated condition shall be chargeable at one-and-a-half times the normal rate.

2. Inspections provided for herein shall be for the purpose of observing the means and methods used by Contractor in the repair and modification of ASME Boiler and Pressure Vessel Code Section VIII metal Unfired Pressure Vessels which are permanently installed at the generating facilities as described in Paragraph 1 above. Such inspection services will be available to Contractor when required, provided Maryland has received sufficient advance notice of the need for such services.

3. The Shop Inspector will be a competent National Board Inspector qualified to pass on A.S.M.E. Code construction or the laws of the locality in which the object will be used, or both, within the United States of America, exclusive of Alaska and Hawaii. Contractor shall prepare the Contractor's Record of Repair covering each object inspected by the field inspector and the field inspector will sign such forms covering work actually examined by him.

4. Contractor agrees to pay Maryland, for the services of such Shop Inspector the sum of Eighty-five ($85.00) Dollars for each regular working day of eight hours or part of a day over one-half (four hours) with a minimum charge of Fifty ($50.00) Dollars for one-half day (four hours or less), plus, in each case all expenses incurred, such as telephone or telegraph charges, traveling expenses and hotel expenses, including meals. Time and traveling expenses shall be computed from the point where such inspector is located at the time the order for such service is received until he returns to that point. No time charge will be made for time of night travel in a public carrier.

5. All charges for services and expenses as outlined in paragraph 4 above shall be paid by Contractor to Maryland at or before the last day of the next following month.

6. It is mutually understood and agreed:

   A. That Maryland shall not be liable directly or indirectly (other than any liability that may be expressed in any policy of insurance that may be issued by Maryland) for any loss, damage or injury to property or persons resulting from any accident to or defect in any object; nor

APCI DOCUMENT NO. 9200205

shall Maryland be liable directly or indirectly for loss, damage or injury of any kind arising from or connected with an inspection or report of inspection, or from the omission of an inspection or report of inspection whether or not such inspection, or report, or omission was at the request of Contractor.

B. It is agreed that Maryland does not assume any liability of any kind arising out of or in connection with the inspection or omission of inspection of any such boilers, unfired pressure vessels and pressure piping or part thereof. Contractor hereby agrees to indemnify and hold harmless Maryland from and against all rights of action, suits, claims and demands of Contractor or any other party and all cost and expense, including counsel fees, because of injury to person or property arising out of or in connection with the inspection or omission of inspection of any such boilers, unfired pressure vessels and pressure piping or part thereof, whether or not such injury is due in whole or in part to the negligence or fault of Maryland, its Inspectors or other employees or agents.

C. That Contractor shall procure and maintain during the life of this contract public liability insurance, including products (completed operations) coverage, for both bodily injuries, or death resulting therefrom, and property damage, with limits of liability to be agreed upon. Such public liability insurance shall include contractual liability insurance against liability assumed under the hold harmless agreement contained in Paragraph 6-B above. Contractor further agrees to furnish the Maryland with evidence of such coverage in the form of current Insurance Certificates, unless said insurance is provided by Maryland.

7. In the event Contractor submits a purchase order for any services covered by this Agreement, such purchase order shall not supersede, terminate or alter any provision of this Agreement. Any hold harmless, non-liability or indemnity provision contained in any such order and any other provision therein which is in conflict with or in any way inconsistent with any provision of this Agreement shall be null and void and all the provisions contained herein shall control.

This is effective _____ and shall terminate July 27, 1969, but may be terminated by either party at any time prior there to by giving thirty (30) days written notice to the other party.

MARYLAND CASUALTY COMPANY

Witness J. J. Bourque — ASST. SECRETARY

V. P. Brennan — VICE-PRESIDENT

AIR PRODUCTS AND CHEMICALS, INC.

Witness C. H. Tyler — TITLE

by V. R. Eveland — Assistant Treasurer — TITLE

Air Products and Chemicals **QUALITY CONTROL LAYOUT**

HYDROSTATIC TEST PROCEDURE

Number: QCL 117A
Effective: 7/1/71
Page: 1 of 2
Supersedes:

I. Purpose

This procedure establishes the requirements and general information to be used when performing hydrostatic tests to prove structural soundness and leak-free construction of manufactured units.

II. Instrumentation

A. Pressure Measurement

1. Use a bourdon tube type pressure gage unless otherwise specified.
2. The gage shall be calibrated per QCL 106K.
3. The maximum dial reading shall be at least 200% but no more than 250% greater than specified test pressure.

B. Temperature Measurement

When required, use glass, immersion type, mercury thermometer, unless otherwise specified.

C. Safety Devices

A small liquid relief valve set to 1 1/3 the test pressure is recommended when vessel is likely to warm up while under pressure and unattended.

III. Test

A. Check for evidence of acceptance by inspection prior to test (Form 6502)

B. Test pressures will be indicated by engineering on drawings.

C. Check accessibility of joints to be tested.

D. Fill unit with clean water.

1. Position unit in a manner which will eliminate all possible air pocket
2. Units containing coiled tubing or cores will require a continuous flow of water until water from the outlet is free of air.

FORM 6520

APCI DOCUMENT NO 99000206

E. Pressurize to specified test pressure and maintain for ten (10) minutes.
   1. Reduce pressure to 80% of the test pressure and maintain long enough to visually examine all pressure bearing joints for leakage.
   2. Units containing brazed joints will be held at the reduced pressure for a minimum of twenty-four (24) hours unless a flux removal operation has preceded the hydrostatic test.
      a. Pressure increase due to warm-up during the test period shall be controlled manually or by use of a Relief Valve as in II-C.
   3. Vessels constructed of more than one chamber or circuit, and designed to operate independently shall have each chamber tested without pressure in the adjacent chamber, prior to testing all chambers simultaneously.

F. Reinforcing plates and saddles or nozzles will be tested per QCL 105A.

IV. Acceptance Criteria

Zero leakage is acceptable as evident by visual inspection. Record test results on Form 6583 and forward to Inspection.

(Retyped 9/27/72 sba)

Air Products and Chemicals

QUALITY CONTROL LAYOUT

PNEUMATIC TESTING - GENERAL

Number: QCL 105A
Effective: 7/1/71
Page: 1 of 3
Supersedes:

I. Purpose

To establish the test method and acceptance criteria for the performance of safe and efficient pneumatic test.

II. Instrumentation

A. Pressure Measurement

1. U-type manometer shall be used to measure pressure under 1 psig.

NOTE: 27.7 inches of water equals 1 psig.

2. Use bourdon tube type gage to measure pressure over 1 psig.
3. The gages shall be calibrated per QCL 106K.
4. The maximum dial reading shall be at least 200% but no greater than 250% of the test pressure.

B. Temperature Measurement

When used, locate a sufficient number of glass immersion type mercury thermometers to obtain average vessel temperature.

C. Safety Devices

A safety relief valve (set approximately 5% higher than test pressure) is recommended for every test to prevent accidental overpressurization of the unit.

III. Test

A. Check for evidence of acceptance by inspection on Form 6502 prior to any test.

B. Test pressures will be indicated by engineering on drawing.

C. Test fluid will be dry oil-free air, dry nitrogen or a premixed combination

APCI DOCUMENT NO 97000202

of 20% helium and 80% dry air.

D. Check condition and pressure rating of test fittings.

E. Check accessibility of joints to be tested.

F. Clear immediate area of personnel.

G. Pressurize slowly to 25 psig and conduct a preliminary soap check. Increase pressure gradually to specified test pressure. Hold for 10 minutes, before reducing to satisfy unit requirements.

1. Soap test all pressure bearing joints.

2. A pressure retention test, recording time, temperature, pressure, manometer readings and barometric pressure readings as required to satisfy a specific requirement.

H. Reinforcing plates and saddles of nozzles attached to the outside of a vesse may be penumatically tested to insure tightness of welds that seal off the inside of the vessel.

IV. Acceptance Criteria

A. Soap Tests - Zero leakage by visual inspection.

Record results on Form 6583 and forward to inspection.

B. Immersion Test, in Place of soap test - Zero leakage by visual inspection.

Record results on Form 6583 and forward to inspection.

C. Pressure retention test - Zero leakage by comparing, final and initial pressures, and final and initial temperatures.

The maximum acceptable difference between actual and calculated final pressures may not exceed 1/2 of 1 per cent of the test pressure.

1. Use the following formula to calculate for final pressure.

$$\frac{TF}{TI} \times (PI) - 14.7 = X$$

TF = Final Vessel Temperature (°C + 273 or °F + 460)

TI = Initial Vessel Temperature (°C + 273 or °F + 460)

PI = Initial Pressure, PSIG + 14.7

X = Final Pressure, Calculated

2. Record test results on Form 7084 and forward to inspection.

TAG OUT PROCEDURE

1. PURPOSE

This safety standard specifies a tag out system for the positive isolation of a circuit, valve or other system where strict safety measures are required for the protection of personnel and equipment. It should be noted that this tag out system is incorporated as a part of the "Construction - Start-up - Safety Control Procedure" Safety Standard 626.3.2 which is specific for that part of a plant's life when construction is being completed and start-up and/or operating activities are underway. This present standard specifies a tag out system that is applicable in every operating plant or manufacturing facility.

2. SCOPE

This standard encompasses all phases of the company's operations pertaining to tag out procedures.

3. PROCEDURE

A. The person having responsibility for the equipment and the work to be done must determine the hazard both to personnel and equipment by review of drawings, flowsheets, specifications, experience or other means, and by a physical inspection of the work site. He can then determine the valves to be closed (or opened as in vents), the electric switches to be opened, etc. to provide a safe working environment.

B. After the valves, switches, etc. have been properly positioned, danger tags shall be filled out and affixed to the equipment. The tear-off portion shall be given to the person(s) who will actually do the work.

C. The valve, switch, etc. shall not be operated nor the danger tag removed until the tear-off portion and the tag are re-united.

D. An up-to-date log of all danger tags and their disposition shall be kept by the person having responsibility for their issuance.

E. After repairs are completed, the man in charge of the repair work shall have a check list of men on the job and see that all men are properly instructed, counted and in the clear before the last danger tag is removed.

F. When the work has been completed and all workers are counted and in the clear, the tear-off portion of the tag shall be returned to the person responsible for the issuance of danger tags. When the tear-off portion has been re-united with the tag, the tag may be removed and the system activated.

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APCI DOCUMENT NO. 22000202

TAG OUT PROCEDURE

3. PROCEDURE (Cont'd)

G. Should the job progress into the next shift, the tear-off portion of the tag will be passed on to the workman doing the work on the next shift. The log is also turned over to the responsible party on the next shift.

H. If any man protected by a danger tag issued to a group should desire, he may also attach his personal danger tag when he starts work on the job and remove it when he leaves.

I. These tags (form 2027) are stocked and may be ordered from Stationery Stores.

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AIR SEPARATION PLANT — SAFETY WORK PERMITS

1. PURPOSE

Due to the nature of our process systems and equipment, and to the hazardous characteristics of some of our products, close control of maintenance and construction work on or in the neighborhood of process equipment must be maintained at all times. The control required to minimize the hazard to personnel and to equipment can be obtained by the system of Safety Work Permits described herein.

2. SCOPE

This procedure shall be used whenever construction, maintenance or repair work is to be done on or in the vicinity of process equipment and any one of the following conditions will be encountered.

A. Outside contractor personnel will be involved.

B. Burning, welding, soldering or other hot work on or near cold boxes, storage tanks, or transfer systems containing liquid or gaseous oxygen or fuel gases.

C. Entry of a tank, vessel, column or cold box.

D. Opening of a process line or vessel.

E. Whenever tag-out of electrical, mechanical or process equipment is required.

F. Creation of a potential hazard in an operating area.

G. Potential hazardous exposure of personnel to process streams or equipment through the normal or emergency operation of process valves, controls, etc.

3. RESPONSIBILITY FOR SAFETY WORK PERMITS

The issuing and control of Safety Work Permits shall be the responsibility of the Plant Manager. The actual work of issuing and controlling the Permits may be delegated by the Plant Manager to the Shift Supervisor or Safety Engineer if the size of the plant and the quantity of work to be done warrants or requires such action.

If the plant or facility is in the process of construction or start-up, the Construction Superintendent or Start-up Superintendent who has the assigned responsibility for the equipment or system shall be responsible for issuing and control of Safety Work Permits.

Air Products ...INCORPORATED	Originated By: H. SMITH	Approved: Safety Director L. BALL	Date 6-19-61

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APCI DOCUMENT NO. 22000202

AIR SEPARATION PLANT — SAFETY WORK PERMITS

4. PROCEDURE

A. No work will be done if any of the conditions noted above under SCOPE exist until a Safety Work Permit has been issued.

B. Safety Work Permits may be issued to cover an area such as would be required for expansion of existing facilities and additions of major pieces of equipment, as well as for work on individual pieces of equipment.

C. The person issuing the permit will survey the area where the work is to be done and the equipment that will be involved to determine that the work can be done safely. It is mandatory therefore, that he be completely familiar with the details of the process equipment, the process flow and work that may be in progress or contemplated in adjacent areas.

D. If Danger tags are required to isolate certain equipment or systems, the tag numbers will be recorded on the Safety Work Permit and the permit will not be issued until the tags are in place. It is the responsibility of the originator to insure that the equipment, system or area has been prepared properly for the work to be performed.

E. Any special precautions or instructions necessary to perform the job safely will be noted on the Permit. If special safety equipment or clothing is required, it shall be specifically noted.

F. The Safety Work Permit will be made out in duplicate and a log made out of its existence and disposition.

G. The original copy will be given to the man or supervisor of the crew, who will be doing the work. The copy will be kept by the originator.

H. If the work continues beyond one shift, the original copy will be passed on to the man or supervisor who is to continue the work. When the work is completed this will be noted on the permit and the permit returned to the originator.

I. The Safety Work Permit shall be considered to be active until it has been physically returned to the originator by the person responsible for the accomplishment of the work.

J. Once a Safety Work Permit has been issued, the originator shall periodically inspect the work site and the work in progress to insure that all special precautions and instructions are being complied with and that there are no hazards to personnel or to equipment.

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5. GENERAL

The Safety Work Permit form can be obtained through the Air Products, Inc. Stationery Stores. Form No. 2026.

AIR PRODUCTS, INC.

SAFETY WORK PERMIT #_____

DATE_____ TIME_____ PLANT_____

THIS FORM TO BE USED FOR ALL WORK ON EQUIPMENT SYSTEMS WHICH HAVE BEEN PLACED IN AN OPERATING STATUS.

NATURE OF WORK TO BE DONE:

1. Hot Work - Burn - Weld - Solder ____
2. Entry - Vessel - Column - Enclosures ____
3. Opening process line or other equipment ____
4. Other (specify) _____

SPECIAL INSTRUCTIONS:

SAFETY EQUIPMENT REQUIRED:

1. Approval of person having control_____ DATE_____
2. Signature of person responsible for work execution_____
   Date_____
3. Work Completed Date_____ Time_____
4. Signature of person certifying work completion_____

Form 2026

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Air Products and Chemicals INC.

RULES FOR CONSTRUCTION OF

PRESSURE VESSELS

DIVISION I

by

American Society of Mechanical Engineers

July 1, 1971

ASME Boiler and Pressure
Vessel Cose, Section VIII,
361P, 1971.

APCI DOCUMENT
ID 99000210

Air Products and Chemicals INC.

QUALIFICATION STANDARD FOR

WELDING AND BRAZING

PROCEDURES, WELDERS, BRAZERS AND WELDING AND BRAZING

OPERATORS

by

American Society of Mechanical Engineers

1971

ASME Boiler and Pressure
Vessel Code Section XI,
88P, 1971.

A-CI DOCUMENT
NO. 99000211

Air Products and Chemicals INC.

NATIONAL BOARD

INSPECTION CODE

by

National Board of Boiler and Pressure Vessel

1968

A Manual for Boiler and
Pressure Vessel Inspectors
150P, 1968.

APCI DOCUMENT
NO. 99[illegible]-2/2

Air Products and Chemicals INC

LEHIGH UNIVERSITY

A COMPARATIVE STUDY OF CRACK PROPAGATION IN PLATES UNDER EXTENSION AND BENDING

by

F. Erdogan
R. Roberts

International Conference
on Fracture Proceedings
Volume 1, PP341-62, 22P,
1965.

APCI DOCUMENT
NO. 2200242

Air Products and Chemicals INC.

LEHIGH UNIVERSITY

EFFECT OF MEAN STRESS ON FATIGUE CRACK PROPAGATION IN PLATES UNDER EXTENSION AND BENDING

by

R. Roberts
F. Erdogan

ASME Winter Annual Meeting

Pittsburgh

11/12-17/66, Trans ASME
SER-D-J, Basic Eng.,
Volume 89, PP885-62, 8P,
December, 1967.

APCI DOCUMENT
NO. 22000-214

Air Products and Chemicals INC.

APPLICATION OF FRACTURE MECHANICS TO SAFE LIFE DESIGN IN CRYOGENIC PRESSURE VESSELS

by

L. L. Loushin
W. J. Lambertin
A. J. Palmer

Esso Report No. EE.26ER.70,
17P, August 24, 1970

APCI DOCUMENT
NO. 99000215

Air Products and Chemicals INC.

LEHIGH UNIVERSITY

FATIGUE-CRACK GROWTH RATES AND FRACTURE TOUGHNESS STUDY OF WELDED ALUMINUM ALLOY 5083

by

J. C. Tafuri
R. Roberts

ASME Winter Annual Meeting - New York

8P, 11/29/70-12/3/70

APCI DOCUMENT
NO. 22000-2/6

Air Products and Chemicals INC.

Date May 4, 1971

INTER-OFFICE MEMORANDUM

Subject Oxygen Safety Review
Check List
(87-1-4141)

To A. Lapin ✓
(Location, Organization, or Department)

From D. R. Latshaw
(Location, Organization, or Department)

cc: L. G. Frederick
C. McKinley

RECEIVED
MAY 13 1971
R. & D. DEPT.

I. Procedure for Solvent Evaporation Technique

A. Procedure

Transfer 250 ml. of the solvent wash sample through filter paper and into a 400 ml. beaker. The sample is transferred with a glass pipette; it is never poured from the sample can. All equipment coming in contact with the sample should have been previously washed with diethyl ether. Evaporate the solvent wash on a steam bath until the volume of solvent has concentrated to 20 to 30 ml. The concentrated volume is transferred into a previously weighed 50 ml. beaker. The 400 ml. beaker is rinsed with four or five small increments of diethyl ether and these increments are transferred to the 50 ml. beaker. The solvent in the 50 ml. beaker is evaporated until no odor of the solvent can be detected. The beaker is placed in a dessicator for half an hour, removed and the unevaporated residue is weighed. The weighed beaker should be handled with crucible tongs, and never handled with the experimentor's hands. The weight of the residue (in grams), minus the weight of the residue from the blank, is multiplied by four and is expressed as grams of soluble contaminants per liter of solvent wash. The blank is determined by evaporating 250 ml. of the same, but unused solvent.

B. Identification

The residue from the sample is smeared between two pressed sodium chloride infrared plates. An infrared spectrum is obtained for the residue, and attempts are made to identify the spectrum. Four of the most typical spectra are identified below.

A typical hydrocarbon oil shows only three major absorption bands. These bands are at 3.45, 6.83 and 7.25 microns.

A cellulube oil shows numerous absorption bands. Some of the major bands are at 10.35, 7.65, 9.00, 6.68, 8.05, 8.40, 8.72, 9.90, 3.30, 3.40, 12.30, 6.20, 6.31, 10.82 and 11.20 microns.

A silicone oil shows five major absorption bands. These bands are at 7.95, 9.20, 9.78, 12.50 and 3.42 microns.

APCI DOCUMENT NO. 12000242

A fluorolube grease shows four major absorption bands. These bands are at 8.30, 8.85, 10.30 and 11.10 microns.

C. Problems

Extreme care must be exercised to see that the following cautions are observed.

1. All equipment coming into contact with the solvent must be previously cleaned with diethyl ether or unused solvent.

2. If the solvent is going to be stored in cans, the cans must be washed with the solvent before they are used. Even if the cans are previously washed with the solvent, experiments have shown that the solvent can extract organic material out of the soldered seams of the metal can. Therefore, the storage time of the solvent in metal cans should be held to a minimum.

3. When storing the solvent in glass bottles, care must be exercised in selecting a top for the bottle. No top containing an inner liner that has some organic material which is capable of being extracted by the solvent can be used.

4. When using a glass apparatus, care must be taken to see that the solvent does not come into contact with any glass joints or stopcocks which would have a silicone lubricant on them.

5. All beakers to be weighed, should be handled with crucible tongs. The beakers should never come into contact with the experimentor's skin.

II. Extraction of Ether Soluble Materials - Oil Content Determination Procedure

A. Apparatus

Soxhlet extraction apparatus (large), 123 x 43 mm. extraction thimble, analytical balance, long-stemmed glass funnel, Whatman No. 41 filter paper, and a 50 ml. pyrex beaker.

B. Procedure

The sample to be separated is placed in a previously weighed extraction thimble. The thimble plus sample is reweighed to obtain the sample weight. The thimble containing the sample is placed in the Soxhlet extraction apparatus containing 250 ml. of anhydrous diethyl ether and extracted for approximately 8 hours. At the end of this time, the thimble is removed and the excess ether which it contains is returned to the Soxhlet apparatus flask. Continue to heat the flask without the condenser portion of the Soxhlet apparatus until the volume of ether has concentrated to 20-30 ml. The concentrated volume is filtered through the filter paper

into a previously weighed 50 ml. beaker. The flask is rinsed with four or five small increments of ether and this is transferred through the filter paper to the beaker. The filter paper is then washed, the rinse entering the beaker. The ether filtrate and washings are heated at a temperature 10 to 15° above that of the boiling point of diethyl ether until no odor of ether can be detected. The beaker is placed in a dessicator for half an hour, removed and weighed. The percent of oil by weight in the sample is calculated by dividing the weight of extracted material, minus the blank, by the original weight of the sample. The blank is determined by weighing the residue obtained upon evaporation of 250 ml. of diethyl ether.

C. Problems

Most of the same precautions listed under problems encountered with the solvent evaporation technique pertain to this extraction technique also.

David R. Latshaw

DRL/plr

AIR SEPARATION PLANT — OPERATION

1. PURPOSE

This check list is presented as an aid to maintain safe operating plants. A periodic inspection should be made by plant management personnel responsible for safety to assure that the plant equipment is in satisfactory condition and that plant personnel observe safe operating practices.

It is also the intent that this check list be used, where applicable, by the start-up supervisor to determine if adequate safety precautions are provided prior to initial plant start-up.

2. SCOPE

This check list is designed for use with air separation plants. However, the major portion of the check list is applicable to other plants such as purification plants, etc. Since the check list reflects the present design criteria, several items in the check list may not be provided for in plants designed and erected in prior years.

The intent of the check list is to be self-sufficient to permit use by operating supervision. Therefore, duplication of portions of the Design Air Separation Check List 610.1.2 will be observed.

3. CHECK LIST

The check list format is such that affirmative answers should be obtained to the questions. Negative answers, if applicable to the particular plant would indicate a possible unsafe condition and corrective action should be taken to eliminate the unsafe condition.

	YES
A. PLANT SITE	
(1) Is the plant remote from neighboring industries and equipment that would present a hazardous condition?	
(2) Is an air analysis made periodically in the vicinity of the inlet air filter if hazardous contamination is possible?	
NOTE: Site, Air Separation Check List is contained in Safety Standard 610.1.1.	
B. PLANT LAYOUT	
(1) Is an adequate safe parking area provided for company employees and visitors' vehicles?	
(2) Is adequate concrete slabbing provided and maintained free of crevices in areas where liquid may be spilled?	

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APCI DOCUMENT NO. 99000-218

SAFETY STANDARDS

610 CHECK LIST

AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)	YES
B. PLANT LAYOUT (Contd)	
(3) Is asphalt confined to areas where liquid oxygen cannot be spilled?	
(4) Is the plant area properly sloped for drainage?	
(5) Is adequate lighting provided throughout the plant?	
(6) Is adequate ventilation provided in the buildings where oxygen or flammable gases might concentrate?	
C. HOUSEKEEPING	
Are good housekeeping habits observed as follows:	
(1) Self-closing metal containers provided for disposal of oil soaked cloths and other flammable materials?	
(2) Aisles marked with safety yellow and maintained clear of material and equipment?	
(3) Areas adjacent to oxygen equipment and piping maintained free of oil and grease?	
(4) Are tools placed in their proper place?	
(5) Are temporary lines kept to a minimum and positioned such that they are not a tripping hazard?	
(6) Are an adequate number of ladders provided, inspected periodically, and equipped with safety feet?	
(7) Are fixed ladders 20 feet or more in height equipped with safety cages?	
D. OPERATING AREA:	
(1) Are ladders and operating platforms provided for valves requiring daily operation?	
(2) Are critical instruments positioned such that the operator has a clear view of them from the operating area?	
(3) Is there adequate operating space?	
(4) Are operators prohibited from using pipe lines, process equipment, or valve stems as steps or operating platforms?	

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Checked by: F. K. KITSON

Approved by: L. BALL

Date: 2-16-61

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AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)	YES
E. PLANT EQUIPMENT	
(1) Air Intake Filter	
a. Is the location of the filter such that venting oxygen and excessive water vapor from the cooling tower will not enter the filter?	
b. Is a "no parking" sign displayed to prevent internal combustion engine fumes from entering the filter?	
c. If oil bath, is approved type oil used? Specify type used. _____	
d. Is the filter cleaned periodically?	
e. Is the cleaning solvent used an approved type? Specify type used. _____	
f. Is the oil inspected weekly?	
(2) Air Compressors	
a. Are lubrication rates maintained at the minimum recommended rate set by the manufacturer or at the rate established by the Machinery Design Section (after break-in of the compressors)?	
b. Are lubrication feed rates recorded for each cylinder on a daily basis?	
c. Are crankcase lubrication rates recorded?	
d. Are the rates normal?	
Are air discharge temperatures maintained lower than the maximum allowed lubricating temperatures listed below:	
Plants larger than 25 T/D:	
e. Hydrocarbon cylinder lubricants, 350°F.	
f. Paraffinic base cylinder lubricants, 365°F.	
g. Fire retardant synthetic cylinder lubricants (Cellulube, Pydraul AC), 385°F.	
Standard Plants	
h. Using manufacturers' recommendations.	

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SAFETY STANDARDS

610 CHECK LIST

AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)	YES
E. PLANT EQUIPMENT (Contd)	
(2) Air Compressors (Contd)	
i. Are all separators blown down at least hourly on each start-up before air is introduced to the plant, and on plant shutdown?	
j. Is the compressor area free of oil leakage?	
k. Is the compressor pad sealed and free of cracks?	
l. Is the compressor motor pit maintained free of oil and provided with adequate drainage to prevent water damage to the motor or electric leads?	
m. Are the motor windings free of dirt and oil?	
n. Is an approved cleaning solvent used on the motor?	
o. Are the coolers inspected periodically for corrosion?	
p. Is the motor of adequate size so that full-time operation on the service factor is not required?	
(3) Caustic Scrubbers	
a. Is the floor maintained free of caustic?	
b. Is the piping and equipment inspected periodically for corrosion?	
c. Is it impossible for caustic solution to backflow into potable water?	
d. Are pump packing spray shields installed?	
e. Is spent caustic discharged into a safe container and safe location?	
f. Are armoured reflex type liquid level gauges or plastic guards provided on the caustic tanks?	
g. Are gauges inspected every six months for serviceability?	

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Originated by [redacted]

Approved: Safety Director [redacted] BALL

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AIR SEPARATION PLANT — OPERATION

	YES
3. CHECK LIST (Contd)	
E. PLANT EQUIPMENT (Contd)	
(3) Caustic Scrubbers (Contd)	
Is the following personnel protection equipment available in good condition, and used by operators:	
h. Chemical goggles?	
i. Face shields?	
j. Aprons?	
k. Dilute vinegar?	
l. Eye and deluge shower?	
(4) Water Wash Towers	
a. Is the water pressure interlocked with the main air compressor motor?	
b. Are the towers and piping checked periodically for corrosion?	
(5) Air Driers	
a. Is the drier precooler separator blowdown performed hourly?	
b. Is the drier filter blowdown performed hourly?	
c. Are negative results obtained when checking for oil by blowdown of the drier filter blowdown valve onto white cloth?	
d. Has the drier filter been free of oil when inspected? If not, what action was taken?	
_____	
_____	
e. Is the reactivation gas 90% purity (or better) nitrogen?	

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SAFETY STANDARDS

610 CHECK LIST

AIR SEPARATION PLANT — OPERATION

	YES
3. CHECK LIST (Contd)	
E. PLANT EQUIPMENT (Contd)	
(5) Air Driers (Contd)	
Is the reactivation cycle maintained with the correct drier outlet temperatures listed below:	
f. Hydrocarbon lubricant in compressor cylinder, 300°F.	
g. Synthetic lubricant in compressor cylinder, 350°F.	
(6) Reactivation Blower	
a. Is the blower shut down immediately in the event that the compressor is shut down or the normal vent gas to the atmosphere is lost?	
b. Is the reactivation inlet valve to the hydrocarbon adsorber shut immediately if the adsorber is on reactivation and the reactivation gas supply is stopped?	
(7) Air Separator	
a. Was a complete plant washout performed after the first year of operation?	
b. What results were obtained after the wash out after the first year of operation? _____	
c. List subsequent complete plant washouts with results. Date_____ Result_____ Date_____ Result_____ Date_____ Result_____	
d. When is the next complete plant washout scheduled? Date:_____	
e. Is the cold box tested weekly for oxygen concentration?	
f. Is the purge adequate (5 psig; 2 psig if supply is large as for example from the low pressure column)?	
g. Is corrective action taken if the oxygen concentration exceeds 21%?	

Originated by:	Approved: Safety Director	Date
F. K. KITSON	L. BALL	2-16-61

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AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)	YES
E. PLANT EQUIPMENT (Contd)	
(7) Air Separator (Contd)	
h. Is the cold box jacket free of frost spots?	
i. Is the box purge taken from the waste nitrogen line off the top of the low pressure column?	
j. Are all valve boots and valve panels sealed?	
k. Are all removalbe panels tightly sealed with an approved sealer (Putti Rope or molded synthetic rubber gasket)?	
l. Is the cold box foundation heated to prevent freezing and heaving of the sub-soil?	
m. Is the cold box pad maintained in a crack-free condition?	
n. Is the cold box area maintained free of dirt and hydrocarbons?	
o. Are an adequate number of "No Smoking" signs prominently displayed in the area?	
p. If the plant is to be shut down for twenty-four hours or longer, is all crude and pure liquid oxygen drained from the plant?	
q. If the period of shutdown is such that the liquid level in the reboiler will drop below one fourth the normal level, is the liquid drained immediately upon shutdown?	
(8) Hydrocarbon Adsorbers	
a. Is the reactivation gas 90% purity (or better) nitrogen?	
b. If a by-pass for the adsorbers is provided, is the by-pass used for start-up only?	
c. Are the recommended reactivation temperatures (inlet, 325°F; outlet, 250°F) achieved?	
d. Is the proper reactivation cycle maintained?	
e. Is the adsorber filter inspected periodically?	

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SAFETY STANDARDS

610 CHECK LIST

AIR SEPARATION PLANT — OPERATION

	YES
3. CHECK LIST (Contd)	
E. PLANT EQUIPMENT (Contd)	
(9) CO_2 Filter	
a. Is the reactivation gas 90% purity (or better) nitrogen?	
(10) Oxygen Pumps	
a. If the sub-cooling medium is oxygen, is the coolant side of the subcooler blown down periodically to prevent accumulation of hydrocarbons?	
b. Is the jacket free of frost spots?	
c. Is the pump box tested weekly for oxygen concentration?	
d. Is corrective action taken if the oxygen concentration reaches 21%.	
e. Is the area maintained free of oil?	
f. Are there an adequate number of "No Smoking" signs in the area?	
g. Is the LOX pump shut down immediately if the air supply to the main heat exchangers is stopped? (This will prevent temperatures below -20°F in carbon steel lines downstream of the exchangers).	
(11) Expanders	
a. Is the area free of oil traces from leakage and misting from the breathers or vents?	
b. Are expander-loader drives guarded?	
c. Is the lube oil make-up rate approximately the same as the recommended make-up rate?	
d. Is the overspeed protection device in operable condition?	

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AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)	YES
E. PLANT EQUIPMENT (Contd)	
(12) Turbo Expander	
a. Is the interlock to shut down the oil pump on low pressure seal air functioning properly?	
b. If belts are used between loading device and engine are all belts in good condition?	
(13) Expansion Engine Oil Separator and Filter	
a. Are the recommended reactivation temperatures (inlet, 600°F; outlet, 500°F) achieved at the inlet and outlet?	
b. Are the filters inspected periodically?	
c. Is the piping design such that the oil separator and filter cannot be by-passed?	
(14) Liquid Storage	
a. Is cross flow of oxygen and defrost gas obtained in the storage tank?	
b. Is the storage box checked weekly at several points to determine the oxygen concentration?	
c. Is corrective action taken if the oxygen concentration reaches 21%?	
d. Are there remote operating shut-off valves at locations where large quantities of LOX or liquid hydrogen are stored and failure of a tank would present an extreme hazard?	
e. Is the storage box jacket or storage tank outer shell free of frost spots?	
f. When was the storage tank last cleaned? Dat _____	
g. Was the cleanliness established by a "black light test"?	
h. Are personnel forbidden to enter empty storage tanks until the atmosphere has been determined to contain a minimum of 18% and a maximum of 25% oxygen?	

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SAFETY STANDARDS

610 CHECK LIST

AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)	YES
E. PLANT EQUIPMENT (Contd)	
(14) Liquid Storage (Contd)	
i. Are safety belts and life lines worn when entering a tank?	
j. Is welding inside tanks forbidden unless positive ventilation of the tank or a self-contained breathing apparatus is provided?	
k. Is the storage of cryogenic liquids in tanks limited to the following capacities:	

Operating Pressure	% Vapor Space (Min.)
Below 40 psig	5.0%
40 to 80 psig	7.5%
above 80 psig	10.0%

l. Are hydrogen tanks checked weekly for trace oxygen?	
m. Are an adequate number of "No Smoking" signs displayed?	
(15) Liquid Transfer Area	
a. Is a minimum of 12 feet of concrete provided on the trailer side of the trailer wheel stop?	
b. Is the concrete pad sloped to permit flow of liquid to the least hazardous area?	
c. Is the concrete pad maintained free of cracks which would tend to permit accumulation of dirt and grease?	
d. Is an adequate trailer wheel stop provided?	
e. Are transfer hoses hydrostatically tested every six months?	
f. Is a fire water protection system provided and in operable condition?	
Transfer Procedures	
Refer to Fleet Safety, Section 635 of the Industrial Safety Standards in the Engineering Standards.	

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AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)	YES
E. PLANT EQUIPMENT (Contd)	
(16) Interconnecting Piping	
a. Are high and low temperature lines and equipment provided with insulation?	
b. Is insulation on oxygen lines of an approved type (Foamglas with Keene binder manufactured by Pittsburgh-Corning)?	
c. Is piping securely supported to eliminate vibration?	
d. Are pipe supports visible for inspection in order that failure of a support may be detected?	
e. Are all sealants other than Teflon ribbon dope prohibited for use in oxygen service?	
f. Are all lines operating at below -20°F (during normal operation, cold shut down, and even plant upset) of non-ferrous or austenitic stainless steel construction?	
g. Are low temperature alarms provided where carbon steel piping temperature could go below -20°F.	
h. Are all vents positioned such that cold liquid or gases and caustic solutions will not discharge into operating areas or impinge on equipment, piping, or power lines?	
i. Are high pressure lines and vessels relieved of pressure prior to working on lines?	
(17) Instrumentation	
a. Are all high pressure gauges (100 psig and over) equipped with blowout plugs or backs and plastic fronts?	
b. Are all oxygen safety valves headered outside the building or vented directly outside the building?	
c. Are all safety valve vents positioned such that cold liquid or gas will not discharge into operating areas or impinge on equipment, piping, or power lines?	

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610 CHECK LIST

AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)	YES
E. PLANT EQUIPMENT	
(17) Instrumentation	
d. Are safety valves protected from extreme weather (freezing rain and snow) to prevent inoperability?	
e. Are all safety valves sealed?	
f. Are safety valves inspected and cleaned at least once a year?	
g. Are safety valves installed in a vertical position? (Malfunction may result if installed in other than the vertical position).	
h. Are leaking safety valves repaired or replaced promptly?	
i. Are plastic fronts used on instruments to prevent shattering and injury to personnel?	
j. Is an oxygen sniffer (equal to Beckman Model D Portable Oxygen Analyzer) available and in good condition?	
(18) Hydrocarbon Testing	
Acetylene Test	
a. Are solutions and apparatus in good condition?	
Are acetylene tests performed as indicated at the following points:	
b. Reboiler condenser (daily)?	
c. Liquid storage (weekly)?	
d. Is corrective action taken immediately if positive results are obtained (plant shutdown is required by responsible authority if results show 2 ppm)?	

AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)

	YES
E. Plant Equipment (Contd)	
(18) Hydrocarbon Testing	
Total Hydrocarbon Analysis	
Is an analysis taken at the following points:	
e. Required - Reboiler liquid, or product line if representative of reboiler liquid?	
f. Required - High pressure air stream after CO_2 removal and prior to any liquifaction?	
g. Optional - Crude oxygen line downstream of the hydrocarbon adsorber?	
Are plant management personnel aware of the action to take if the following results are obtained:	
h. Any upward trend of hydrocarbon concentration deviating from the established normal range? (Investigation and corrective action required in the event of this condition.)	
i. An increase above 500 ppm, this limit is lower for plants located in areas where low solubility hydrocarbons are present in the atmosphere due to neighboring industries? (Plant shutdown, dumping of liquid, and corrective action to eliminate cause is required by responsible plant authority.)	
(19) Gas Storage and Cylinder Charging	
NOTE: Refer to Section 610.2.1 General Acetylene Check List of the Safety Standards for acetylene producing plants.	
a. Are oxygen cylinders maintained a minimum distance of 20 feet from flammable gas cylinders unless separated by a masonry partition?	
b. Are oxygen cylinders and flammable gas cylinder areas clearly identified?	
c. Are empty and full cylinders segregated?	
d. Are areas for empty and full cylinders clearly identified?	
e. Is the storage area and charging area free of flammable materials?	

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AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)

YES

E. Plant Equipment (Contd)

(19) Gas Storage and Cylinder Charging (Contd)

f. Are aisles marked with safety yellow and maintained clear?

g. Are cylinder caps installed when cylinders are not in use, or are being moved?

h. Are an adequate number of "No Smoking" signs displayed?

(20) Material Storage

a. Are all chemicals and oils properly labeled?

b. Is the intended use for the various materials noted?

c. Is solvent and paint storage segregated from less volatile material and from oxygen equipment and piping?

d. Are "No Smoking or Open Flame" signs posted?

e. Are all spare parts labeled with appropriate Material Code number and stored in an orderly manner?

f. Are hydrocarbon decontaminated parts sealed to prevent recontamination?

g. Are spare parts carefully examined prior to installation to determine their adequacy for temperatures and pressures involved?

h. Are all threading sealants, packing materials, etc. suitable for oxygen service? (Any material not approved for oxygen service should be disposed of or tagged: "Do Not Use in Oxygen Service".)

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AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)

	YES
F. PLANT SAFETY AND FIRE FIGHTING EQUIPMENT	
(1) Plant Safety Program	
a. Are monthly safety meetings held?	
b. Is safety literature posted on the safety bulletin board and discussed in safety meetings?	
c. Is the safety committee active?	
d. Are new employees instructed in safety?	
e. Are employees trained in first aid?	
f. Is a doctor's name, address, and phone number prominently displayed in several locations?	
g. Are alternate doctors also listed?	
h. Are employees trained in the use of fire extinguishing equipment?	
i. Is a private fire brigade organized?	
j. Is the local fire fighting organization's phone number displayed in several locations?	
k. Has the local Fire Department been contacted to determine what equipment they have available and to familiarize them with potential hazards in the plant?	
(2) Safety Equipment	
Is the following safety equipment provided and used:	
a. Gloves?	
b. Safety glasses with side shields?	
c. Chemical goggles?	
d. Face shields?	
e. Approved flashlights (M.S.A. permissible or equal)?	
f. Explosion-proof hand lamps?	

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SAFETY STANDARDS

610 CHECK LIST

AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)	YES
F. PLANT SAFETY AND FIRE FIGHTING EQUIPMENT (Contd)	
(2) Safety Equipment (Contd)	
g. Safety hats?	
h. First-aid supplies?	
i. Stretchers?	
j. Gas mask or blower mask?	
k. Respirators?	
(3) Plant Operations	
a. Are up-to-date operating handbooks available?	
b. Are the handbooks used?	
c. Is the work permit system used?	
d. Is safety tagging used?	
e. Is plant management familiar with state and local codes?	
f. Is advantage taken of assistance from the State Industrial Commission?	
g. Is safe plant operation reviewed regularly with plant operators?	
h. Are all electric hand tools properly grounded?	
(4) Fire Fighting Equipment	
a. Are an adequate number of fire hydrants located in the plant area or adjacent to the plant?	
b. Are fire hoses hydrostatically tested to 150 psig for three minutes every twelve months?	
c. Are fire hoses readily accessible and maintained in good operable condition?	

AIR SEPARATION PLANT — OPERATION

3. CHECK LIST (Contd)

	YES
F. PLANT SAFETY AND FIRE FIGHTING EQUIPMENT (Contd)	
(4) Fire Fighting Equipment	
d. Are fire blankets available, mounted in canisters on walls, and in accessible locations?	
e. Are an adequate number of fire extinguishers provided in the plant?	
f. Is a visual inspection of all fire extinguishers made every month?	
Is a visual inspection of fire extinguishers made every other month for:	
g. Broken seals?	
h. Weight, or if liquid, is it full?	
i. Condition of hose?	
j. Pressure gauge, if applicable?	
k. Nozzle?	
l. Ticketing?	

NOTE: If a seal is broken on any extinguisher, it should be treated as though it is empty and a thorough inspection should be made.

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AIR PRODUCTS LOW-TEMPERATURE PROCESSING EQUIPMENT

HANDLING OF LOW-TEMPERATURE FLUIDS AND HIGH-PRESSURE OXYGEN

BY

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Director of Safety
Air Products, Incorporated
Allentown, Pennsylvania

Presented by W. Leonard Ball at the Aeronautical Industries
Section program of the National Safety Congress,
Chicago, Illinois;
October 19, 1959

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AIR PRODUCTS LOW-TEMPERATURE PROCESSING EQUIPMENT

Energy, highly concentrated, each thimbleful potent yet packaged, transferred, and stored in tonnage lots--this characterizes the low-temperature fuels and oxidants which power missiles. Their intentional and efficient combination in a missile engine can propel a ton of material (in a small number of packages) thousands of miles into space. Their unintentional combination, even with less efficiency, may yield some fraction of the same result, possibly propelling a large number of packages comparatively smaller distances across the surface of the earth. Herein lies a safety problem. High-energy propellants are essential to missile success, yet, they must be prepared and handled in such a manner that their high energy remains impotent until demanded.

Hazards associated with cryogenic fluids can be broken down into four categories.

1. Personnel exposure to extreme cold or to inert or toxic gases.

2. Brittleness of structural materials at low temperatures.
   (This may not be a hazard in itself but can contribute to personnel exposure or to the formation of flammable mixtures.)

3. High pressure arising from confinement of liquids and gases.

4. Flammability.

We will give our greatest consideration to number 4, since the elimination of unintentional flammable mixtures is the most serious problem.

Most of our attention will be focused on a common low-temperature oxidant, liquid oxygen and on the lowest-temperature fuel, liquid hydrogen. Since high-pressure gaseous oxygen presents flammability problems closely related to liquid oxygen, it will also receive emphasis. Inert low-temperature liquids such as nitrogen and helium will be mentioned only briefly. Since this subject is very broad and not all avenues can be pursued in the available time, we will allow a substantial discussion period, where some of your interests may be more fully developed.

Let's look at liquid oxygen. Commercial producers and handlers set primary emphasis for safety on fuel control, with secondary consideration to prevention of ignition. To control fuels, we must know what they are and when they reach a flammable range. With respect to liquid oxygen, we can class fuels into three groups.

1. Soluble hydrocarbons.
2. Insoluble hydrocarbons.
3. Other materials, including some inorganics not usually classed as fuels.

Soluble hydrocarbons will burn or explode in liquid oxygen only if their lower flammability limits are exceeded. Although no extensive data on liquid oxygen-hydrocarbon flammability limits has been published, a paper entitled "Oxygen Plant Safety Principles", appearing in CHEMICAL ENGINEERING PROGRESS in March 1957, points out that liquid phase limits will not be lower than the gas phase limits available in many publications. Figure 1 shows the flammability envelope of the system methane, oxygen, nitrogen. The point labeled "oxygen" represents 100-percent oxygen, the one labeled "nitrogen" represents pure nitrogen, and the other corner pure methane. The side of the triangle opposite the oxygen corner represents 0-percent oxygen. Likewise, the sides opposite methane and nitrogen represent zero composition for those substances. Note that the shaded area indicates mixtures of these substances which are flammable. Outside of the shaded area no combustion can take place. Considering mixtures of methane and oxygen only, with no nitrogen present, we focus our attention on the base

line connecting the methane and oxygen corners. This is the 0-percent nitrogen line. Note that the corners of the envelope intersect the line at 5-percent methane and at 61-percent methane. These are the gas phase flammability limits of methane in oxygen.

The dotted line within the envelope represents flammability limits of liquid methane in liquid oxygen, as determined at Air Products' Research Laboratory, using a No. 6 dynamite cap as an initiator. The initiator is mentioned because, conceivably, the liquid phase envelope could approach the gas phase limits more closely if stronger initiation were applied. However, from both theoretical and experimental considerations, it is apparent that the lower gas phase limit will not be greater than the lower liquid phase limit. It enables us to apply well-known gas phase flammability limits to the definition of safe soluble hydrocarbon levels in liquid oxygen. It has practical significance insofar as oxygen, as produced by air separation, will normally contain far greater quantities of th lighter, more soluble hydrocarbons. For example, methane may commonly be found in the 5- to 50-parts-per-million range, whereas all heavier hydrocarbons combined will seldom exceed 2 parts per million. By consulting tables, such as the first column shown in figure 2, we see that, as long as hydrocarbons are soluble, their lower flammable limits are in "percent" ranges, and that the lower limit of detonation requires an even higher percentage of impurity. Since we have just stated that liquid oxygen, as produced, seldom contains more than a few parts per million of hydrocarbons, it is obvious that an extremely abnormal condition is required to yield flammable mixtures in solution.

As an introduction to the case of insoluble hydrocarbons, refer to figure 3. When impurities exceed their solubility and come out of solution, forming islands of solid within or on the surface of liquid oxygen, it is evident that localized flammable mixtures can occur even though the average concentration throughout the system may be far below the flammable range. Knowledge of solubilities, then, is an important factor in establishing liquid oxygen safety principles. Note the dependency of solubility on temperature. Subcooling liquid oxygen may cause a contaminant to come out of solution. Note the position of the saturated hydrocarbons, methane, ethane, propane, and pentane. Solubility decreases as the "C" number increases. Comparing ethane with ethylene, note that unsaturates are less soluble than saturates of the same "C" number. Acetylene, also a C_2, is much lower. Figure 4 shows the "C" number or carbon atom content plotted against solubility for saturates. The unsaturates and more complex hydrocarbons would fall beneath the curves shown. From a practical standpoint, by extending the trend that we see here, it is apparent that oils and greases which have "C" numbers well above 6 will have liquid oxygen solubilities far below 1 part per million. Normal liquid sampling and analysis techniques (useful in safeguarding against more soluble hydrocarbons) are not capable of detecting the approach of insolubles to hazardous concentrations.

Another thought to keep in mind is that most impurities in liquid oxygen have boiling points much higher than oxygen; hence, their vapor pressures at the temperature of boiling oxygen are extremely low--in most cases, negligible. As oxygen vaporizes, the impurities concentrate.

Our third group of fuels was included to point out that some materials, not flammable in air, can be burned in pure oxygen, and more energetically as the oxygen density increases. Some of the metals bear this out very vividly. In an oxygen safety demonstration, which we give on occasion at Air Products, a series of tests are shown.

First, using an oxyacetylene torch, we heat carbon steel to its melting point. Then we close the acetylene valve, directing only oxygen gas onto the red-hot carbon steel. As we all know, the carbon steel supports its own combustion in pure oxygen gas even at atmospheric density. Although carbon steel is used extensively in oxygen distribution systems, pressure and flow velocity limitations are applied.

The second step of the demonstration is to direct the oxyacetylene flame onto stainless steel. When molten state is reached and the acetylene is cut off, the oxygen from the torch actually cools the stainless steel. It does not sustain its own combustion. Aluminum acts the same way.

Step number three is to heat carbon steel to its melting point and to allow the molten drops to fall into liquid oxygen. Naturally, it burns violently.

Then this experiment is repeated with stainless steel. It also burns violently and even more brightly than carbon steel. It can support its own combustion in liquid oxygen.

Finally, aluminum is used. Molten aluminum dripping into liquid oxygen does not burn, yet we know that finely divided aluminum will burn briskly, even explosively, in liquid oxygen.

Looking back at the behavior of stainless steel, one might ask, "Where is the dividing line? Will it burn in high-pressure oxygen?" Commercial experience, at pressures up to 3,600 pounds, seems to indicate that some additional fuel, more easily ignited, must be present to sustain a stainless steel-oxygen fire. However, I have been told of one case where a stainless system was pressurized very rapidly with oxygen and immediately exploded, with every indication that the stainless played an active part in the reaction. The only other conceivable fuel in the system was a small nylon diaphragm, which could have initiated the reaction, but certainly was not sufficient fuel to cause extensive damage to the system. Let's look at figure 5. If oxygen is compressed adiabatically, and in a practical system that means fast enough so that no heat is transferred to the walls, the curve shows us that ignition temperatures for most substances, including some metals, can be attained through adiabatic compression to commercial cylinder pressures.

Up to this point, we have talked about some aspects of the combustion hazard with liquid and high-pressure oxygen. Let's look now at methods of prevention.

First, against soluble hydrocarbons. Vigilant monitoring and adsorptive purification are practiced extensively by commercial producers. Frequent acetylene analysis is a "must" at air separation plants. Analysis for total hydrocarbons or for certain individual hydrocarbons is also carried out at most of the larger plants. Solubility is the primary key for the establishment of safe limits.

Silica gel is the most commonly employed adsorbent for purification. Adsorbers can be found in most air plants. Figure 6 shows the adsorptive capacity of silica gel for various hydrocarbons in liquid oxygen. Remembering the solubility data of figures 3 and 4, the important thing to notice is the increase in adsorptive capacity of the silica gel as the liquid oxygen solubility of the impurity decreases.

This brings us to preventive measures against insoluble hydrocarbons. Obviously, adsorptive purifiers can help to protect against transfer of these contaminants from one part of a system to another. By recirculation through purifiers attached to storage vessels, concentration due to vaporization can be eliminated (for both soluble and

insoluble materials). But so far as insolubles such as oils and greases are concerned, adsorptive purifiers in the air plant have already lowered their levels below the perceptible threshold of most analytical devices. The most serious problem exists not in the liquid, but in the system through which it flows. This is even more true in high-pressure gaseous systems supplied by liquid vaporizers. Insoluble impurities do not vaporize at low temperatures. Their entrance into the system comes during periods of construction, maintenance, and also from improper attempts at cleaning. The major defense is a rigid cleaning procedure, followed by careful inspection.

For the third group of fuels, which we exemplified by carbon steel, stainless steel, and aluminum, the defense lies in choice of material, avoiding those which are easily ignited. Materials not normally flammable in air will generally require strong ignition to burn in oxygen, so with this class of fuel, elimination of ignition agents can be pursued with realistic assurance of success--this is not true in the case of soluble or insoluble hydrocarbons.

By no means have all the safety aspects of handling liquid and high-pressure oxygen been covered, but let's defer others to the discussion period and move to other liquids.

All cryogenic fluids are handled at temperatures below -200°F, cold enough to damage human tissues. Closed systems are to be used as much as possible. The use of flexible connectors and temporary couplings should be minimized. Obviously, wherever there is a chance of a leak, protective clothing must be used.

Brittle failure of materials can be avoided through careful design and properly supervised part replacement. Operating procedures must be checked to guarantee that equipment designed for warm service will not be chilled unintentionally.

Fractures and spillage, caused by pressure build-up from excessive vaporization in closed systems, can be avoided if liquid is stored and transferred only in vessels and lines specifically designed for low-temperature service. Proper attention must be given to selection, location, and maintenance of relief devices. Any segment of a system capable of isolation must have relief protection. Wherever possible, vacuum insulation space should be filled with powder or equivalent insulating material.

Nitrogen and helium do not support life. This is a rather obvious statement, but it has two safety implications.

1. People entering toxic or flammable gas or liquid storage vessels, which had just been made safe by inert gas purging, have had the embarrassing experience of finding themselves without breathing apparatus.

2. Where liquid vessels in particular are located in small rooms, the popping of a relief device may significantly lower the oxygen content of the room.

Now let's turn to liquid hydrogen, comparing it with a common fuel such as propane.

By referring to figure 7, we can make a number of comparisons:

Hydrogen vaporizes at -423°F, propane at -44°F. Since the surfaces of the earth and its adornments are seldom below -44°F, the exposure of liquid hydrogen to the atmosphere will result in an initial temperature difference 380 degrees greater than the exposure of liquid propane to the same environment. Heat will flow more

readily across the higher gradient to the liquid hydrogen. Now let's look at liquid densities. If the same volume were spilled onto the same surface area, almost nine pounds of propane would cover the same space as one pound of hydrogen. On a pound-mole basis, the latent heat of propane is more than twenty times that of hydrogen. Many more BTU's are required to vaporize an equal volume. All of these point to extremely rapid dissipation of liquid hydrogen compared to propane. Alcohol and gasoline, very volatile in the normal sense, vaporize even slower.

Now let's look at gas density. We have heard about cold oxygen clinging to the ground and filling ditches because cold oxygen is more dense than air. Even at 70°F propane is considerably heavier than air. Hydrogen gas at -420°F is about as dense as ambient air, but thins rapidly to 6 percent of that value when warmed to ambient conditions. Only slightly warmed, it will rise rapidly. Comparison of diffusion, thinking now in a three-dimensional sense, shows that hydrogen disappears into the atmosphere in all directions far more quickly than oxygen, whereas liquid fuels require lengthy exposure before they will disappear.

When exposed to ambient conditions, hydrogen will be vaporized, warmed, and dissipated far more rapidly than other fuels. We might say that its exposure index is extremely small.

Considering now its combustion characteristics, we may refer to figure 8, which shows us that when hydrogen is mixed with air, it is flammable over a broader range of mixtures than most other materials. Moreover, hydrogen is more easily ignited than other fuels, it has higher flame velocities, and is more difficult to extinguish. Compared to household fuels, hydrogen demonstrates some additional degree of hazard in these respects.

However, we can see that the dissipation and combustion properties work both ways. Rapid dissipation suggests the problem will go away before it becomes a problem. A broad range of flammable concentrations, coupled with low energy for ignition, enhances the probability of combustion during the exposure period. The resistivity of the flame to cooling, as suggested by quenching distance, explains why sustained flames are difficult to extinguish. On the other hand, rapid dissipation precludes sustained flames in open space. Low radiation and short flame duration limit fire effects on adjacent equipment not directly contacted by the flame. You may draw your own conclusions regarding the degree of danger.

Liquid hydrogen is a stable material in the normal sense of the word, and to quote one of the military safety bulletins, "Liquid hydrogen is unaffected by extreme cold." Although hydrogen embrittlement of metals is a frequent cause of trouble in higher temperature operations, no embrittlement has been reported in liquid systems.

Three major circumstances or conditions of hazard can exist in conjunction with liquid hydrogen systems. The first of these is the presence of oxidants in the liquid hydrogen.

A second potential hazard, perhaps the major one, is that of spilling.

A third hazard, and perhaps the most frequent one, is that of vented gas.

Let's look at each one of these, considering the effect and then the methods of prevention or control.

First, oxidants in liquids. What can happen? In an early experiment at Boulder, Colorado, oxygen was condensed deliberately into a Dewar of liquid hydrogen. It was ignited by a spark. Result--no Dewar. Several steps can be taken to prevent entrance of an oxidant into liquid:

1. The entire system should be completely closed and maintained above atmospheric pressure during all operations.

2. The liquid hydrogen must be admitted in a completely pure state, oxidants having been removed by adsorption, filtration, or catalytic oxidation.

3. Vessels and pipes must be properly purged.

4. Accumulation of trace impurities in storage tanks should be avoided.

Figure 9 depicts a spill test simulating a broken line. Other spills, up to thousands of gallons through holes 24 inches in diameter, have resembled ruptured tanks. Results have shown extremely rapid dissipation with no high probability of spontaneous ignition. Flammable mixtures appear to be confined within the visible condensate cloud, and when ignited by sparks, flames are of short duration and radiate less energy than propane or gasoline flames.

We have discussed the possible effect of spills. Let's look at methods to prevent them:

1. Materials of construction must be suitable for low-temperature service.

2. Relief devices must be installed in all systems capable of being blocked.

3. Field welds should be stamped and coded. Fabrication must be followed by stringent pressure and leak testing.

4. Remote shutoff valves should be installed on major vessels or on both ends of long transfer lines.

5. Powder insulators should be used in the evacuated space around vessels, since they afford reasonable insulation in case vacuum is lost.

Furthermore, specific design precautions can minimize the effects of a spill if it does occur:

1. Dispersion must be enhanced. Barricades should not be installed around tanks. Dikes should be used sparingly, only to prevent liquid flow in an undesirable direction. Full advantage should be taken of prevailing winds in planning plant layout.

2. Sources of ignition should be excluded insofar as possible.

3. Suitable quantity-distance relationships should be established.

4. An adequate supply of water should be available to prevent the spread of a fire to less flammable but slower burning surroundings.

Now, what about venting? Cold gas may settle: warm gas will rise. Vent stacks should be long and high, sized to warm the largest vent stream anticipated, not only during normal cooldown or transfer venting, but to meet the needs of emergency venting should vacuum be lost.

Two precautions must be taken. A sealing lid, which is easily lifted but which seals tightly, should be installed to prevent air from entering the stack before or after use. The stack should be kept clean. High-velocity particles could cause ignition at the mouth of the stack.

Thus, for each circumstance or condition of hazard, we can subscribe methods for prevention or control.

Let's conclude by looking at some general rules for safe handling of liquid hydrogen:

1. Provide good ventilation to operating areas.
2. Purge all equipment with an inert gas before adding and after removing hydrogen.
3. Monitor the system for oxidants and the surroundings for hydrogen.
4. Make all transfers in closed, carefully prepared systems.
5. Use approved or isolated electrical equipment.
6. Provide protection against lightning, static build-up, and sparks.
7. Allow no open flame or smoking in the area.
8. Above all, inform all personnel of potential hazards, and thoroughly acquaint them with the design features and operating procedures which have been set forth to neutralize the hazard potential.

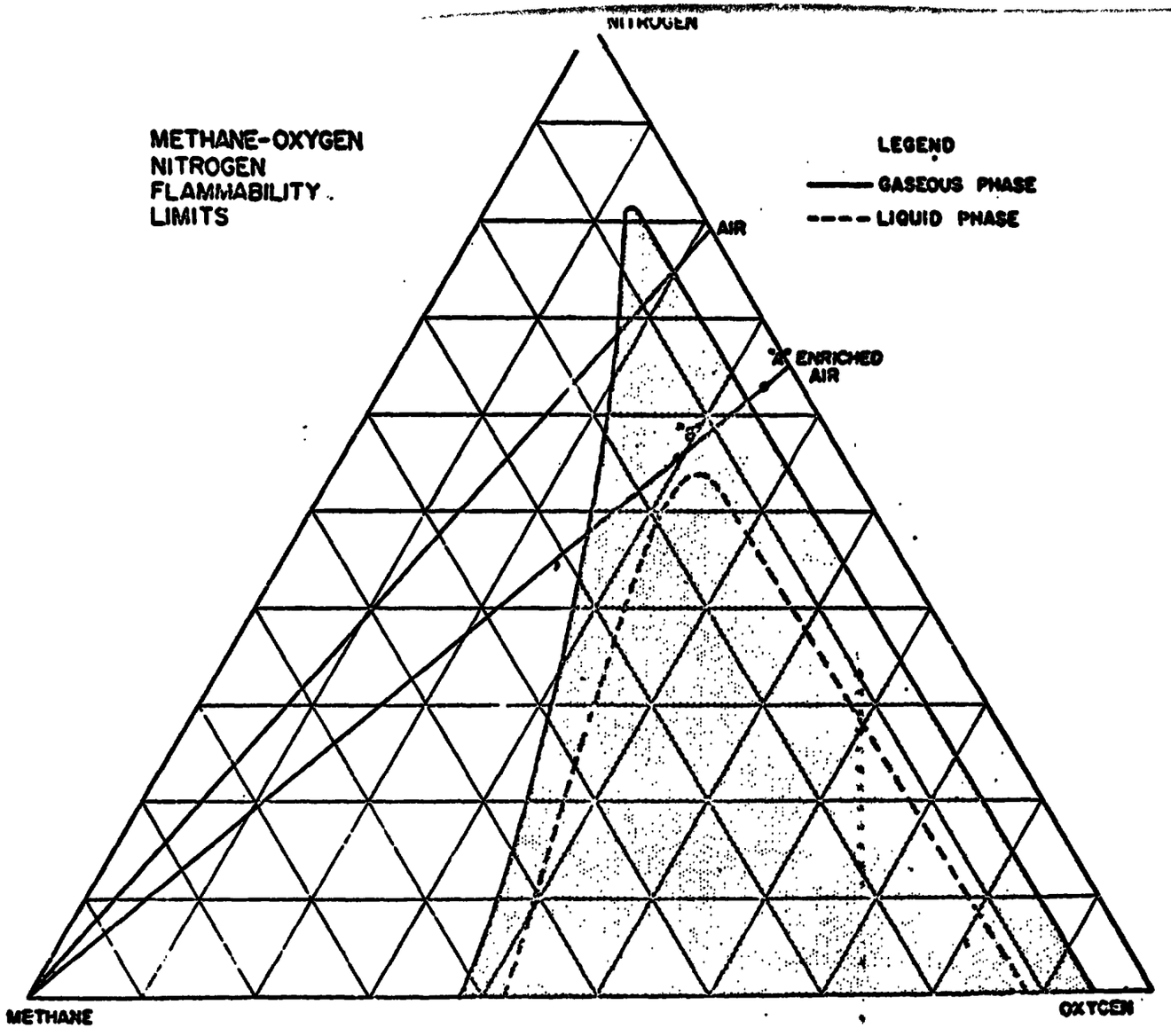


Figure 1

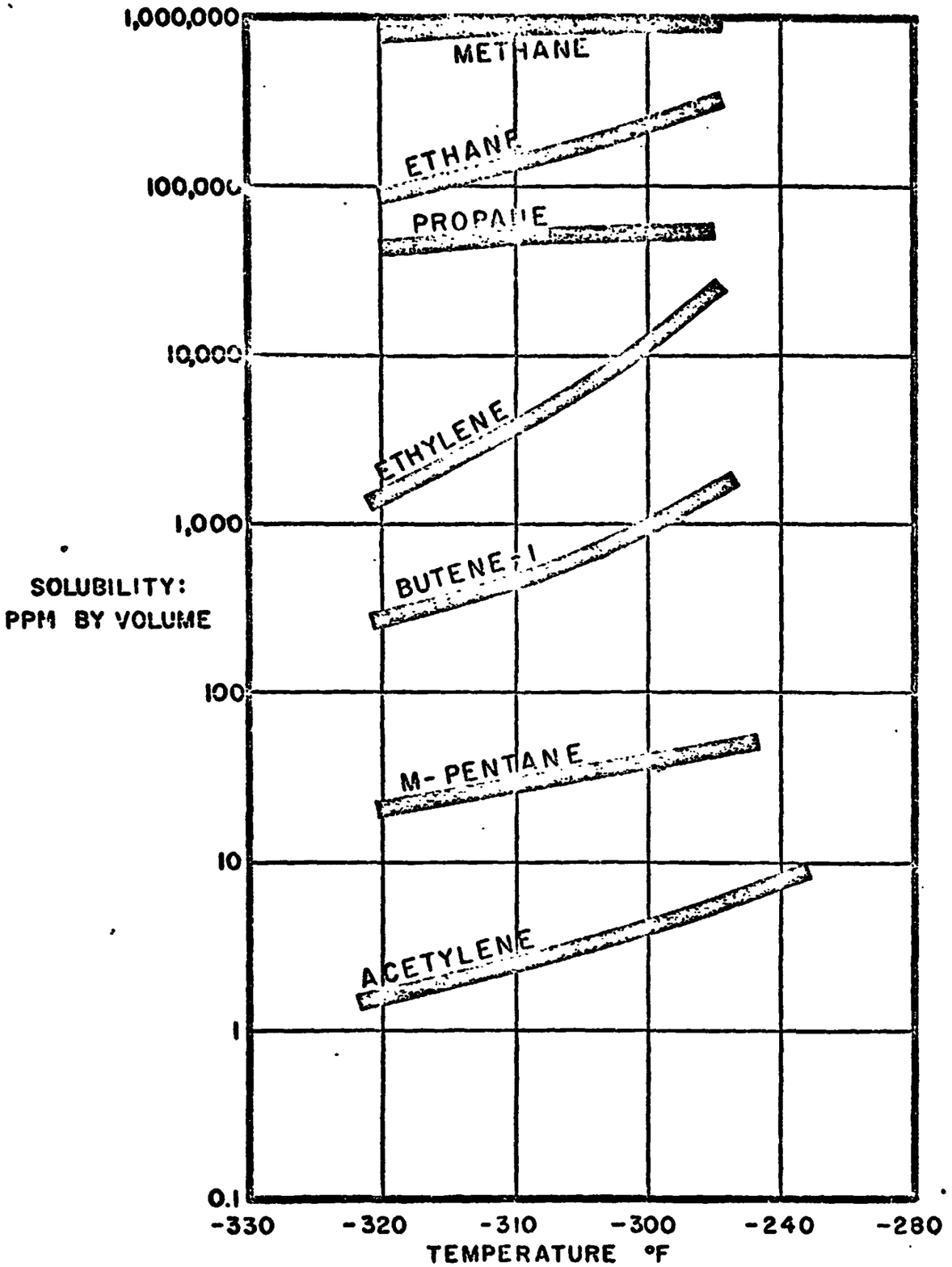
Reference: Himmelberger, F., "Control of Contaminants in Air Plant Reboilers Introductory Remarks to the Topic of Reboiler Safety at the Air and Ammonia Plant Safety Symposia. AICHE Salt Lake City Meeting, September 1958.

Flammability and Detonability Limits——Gases

Mixture	Lower Limit, Mole % flammability	Lower Limit, Mole % detonability	Upper Limit, Mole % detonability	Upper Limit, Mole % flammability
H_2 ___ O_2	4.65	15	90	94
H_2 ___ air	4.0	18.3	59	74
CO ___ O_2 (moist)	15.5	38	90	93.9
CO ___ air	12.5	....	....	74.2
CH_4 ___ O_2	5.4	....	.....	59.2
CH_4 ___ air	5.0	....	....	15.0
C_2H_2 ___ air	2.5	4.2	50	80
$C_4H_{10}O$ (ether) ____ O_2	2.1	2.6	40	82
$C_4H_{10}O$ ____ air	1.85	2.8	4.5	36.5
C_2H_6 _____ O_2	4.10	....	....	50.5
C_2H_6 _____ air	3.0	....	....	12.5

Figure 2

Reference: McKinley, C. and Himmelberger, F., "Oxygen Plant Safety Principles" published in "Chemical Engineering Progress," March 1957.



SOLUBILITY OF HYDROCARBON IN LIQUID OXYGEN

Figure 3

Reference: McKinley, C. and Wong, E. S. J. Hydrocarbon - Oxygen Systems Solubility presented before the National Bureau of Standards

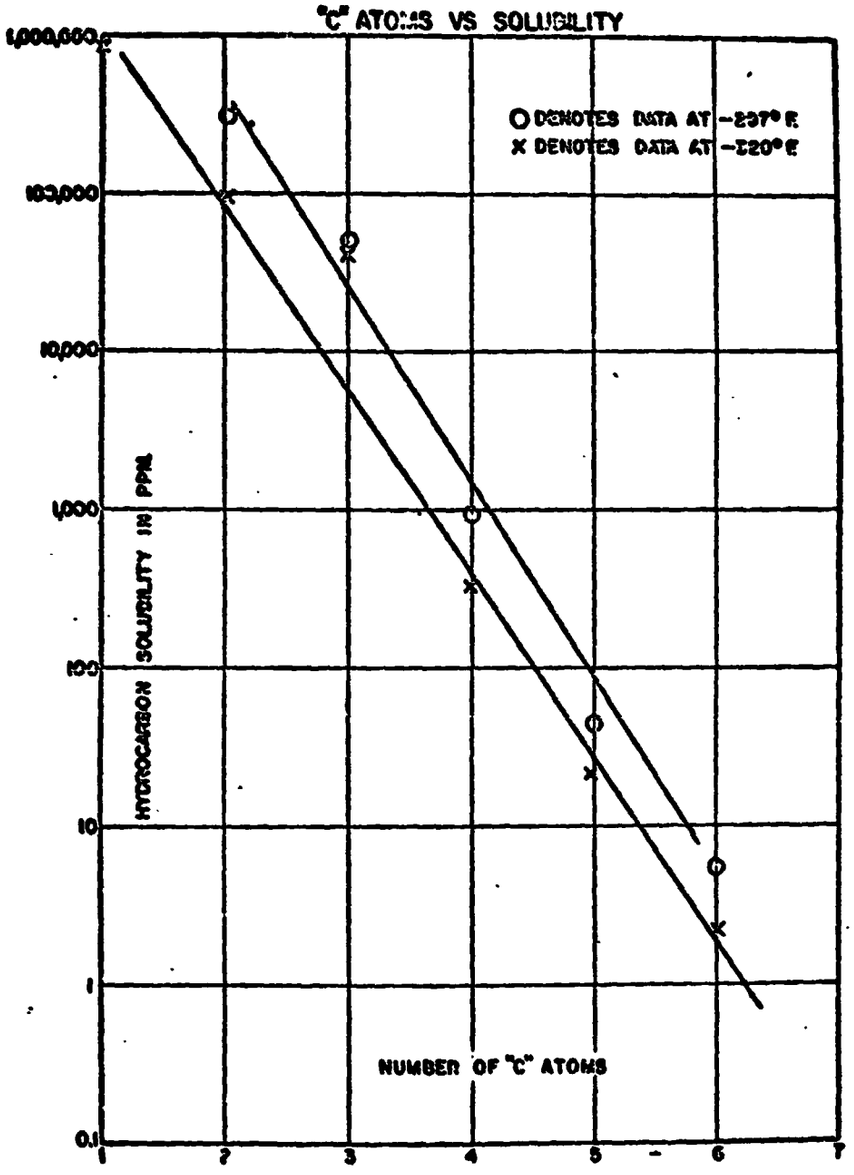


Figure 4 Carbon Atom Content versus Solubility for Saturates

Reference: McKinley, C. and Wong, E. S. J., "Hydrocarbon - Oxygen Systems Solubility" presented before the National Bureau of Standards Cryogenic Engineering Conference, Cambridge, Massachusetts, September 3, 1958.

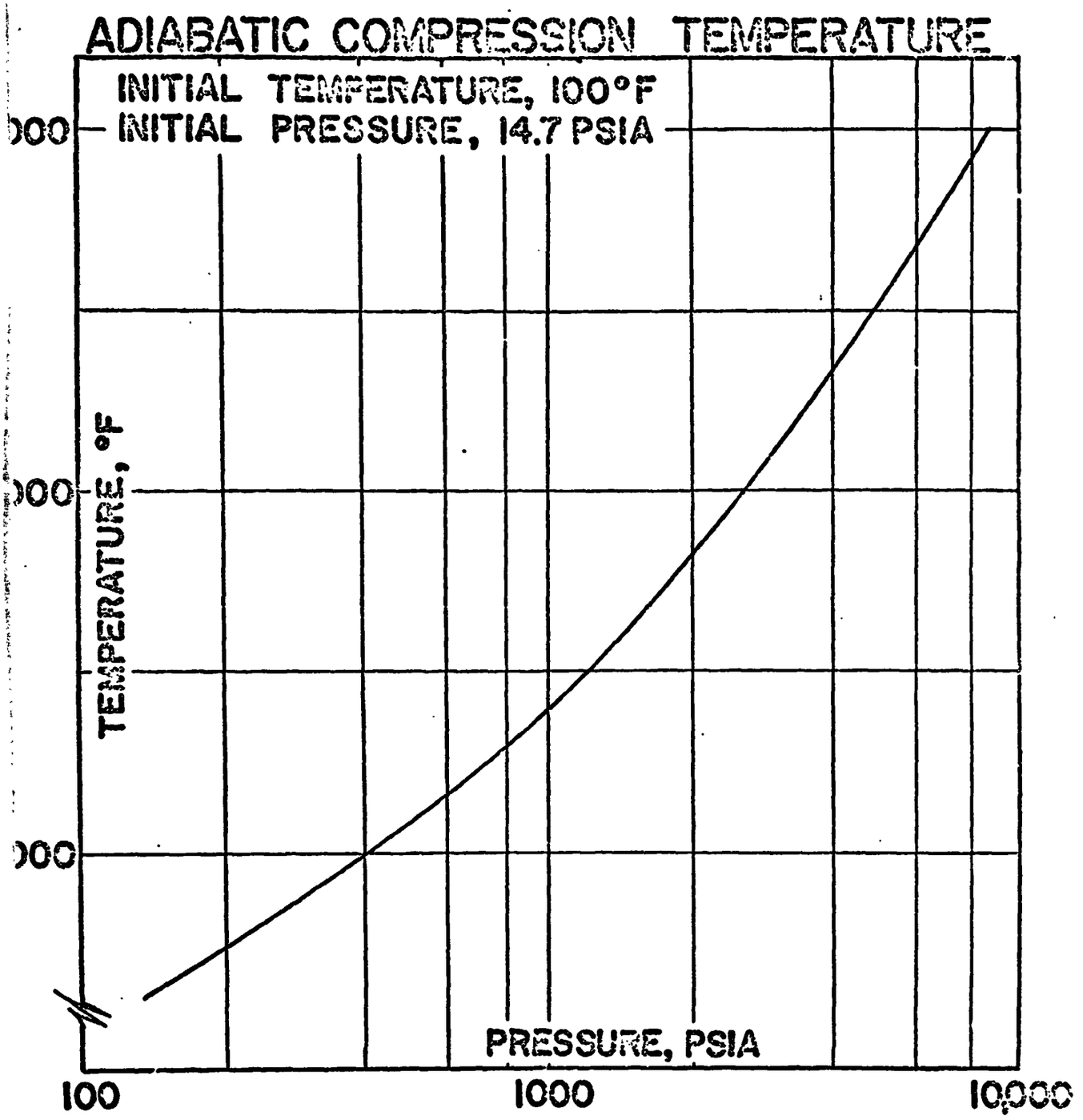


Figure 5

Reference: McKinley, C., "Technical Character of Cryogenic Hazards" presented at Air Products, Incorporated Safety Conference, July 1959.

ADSORPTION OF ETHYL[illegible]NE, ETHANE AND METHANE

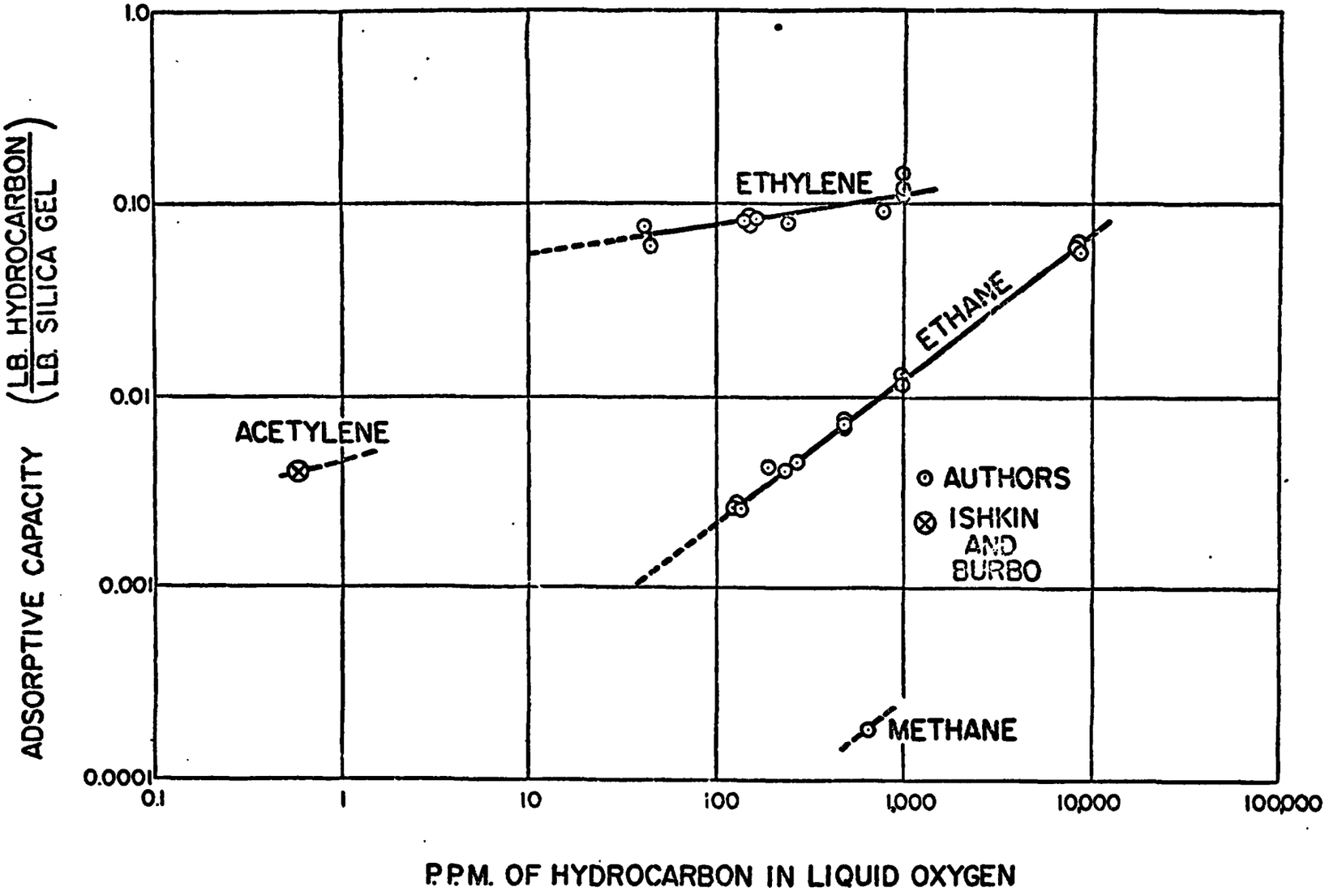


Figure 6

Reference: McKinley, C. and Hsu, A. C. T., "Adsorptive Purification of Liquid Oxygen" presented at the Low Temperature Processing Symposium American Institute of Chemical Engineers

SOME PHYSICAL PROPERTIES

OF

HYDROGEN, PROPANE, OCTANE, OXYGEN, AND AIR

	H_2	C_3H_8	C_8H_{18}	O_2	AIR
BOILING POINT, ^oF	-422.99	-43.7	+258.2	-297.3	-317.9
LIQUID DENSITY, LB/FT^3 @ B.P.	4.43	36.2	44	71.2	54.57
LATENT HEAT, BTU/LB-MOL	389	8076	16,620	2932	2556
GAS DENSITY, LB/FT^3 AT 70^{o}F, 1 ATM.	.00522	0.1154	--	.0828	.07493
LIQUID TO GAS EXPANSION RATIO, B.P. TO 70^{o}F	851.33	--	--	862	726.13
DIFFUSION COEFFICIENTS (INTO AIR) GM/CM^2/SEC	.68	--	--	.17	--

Figure 7

Reference: Himmelberger F., "Liquid Hydrogen Safety" presented at Air Products, Incorporated Safety Conference, Jul· 1959.

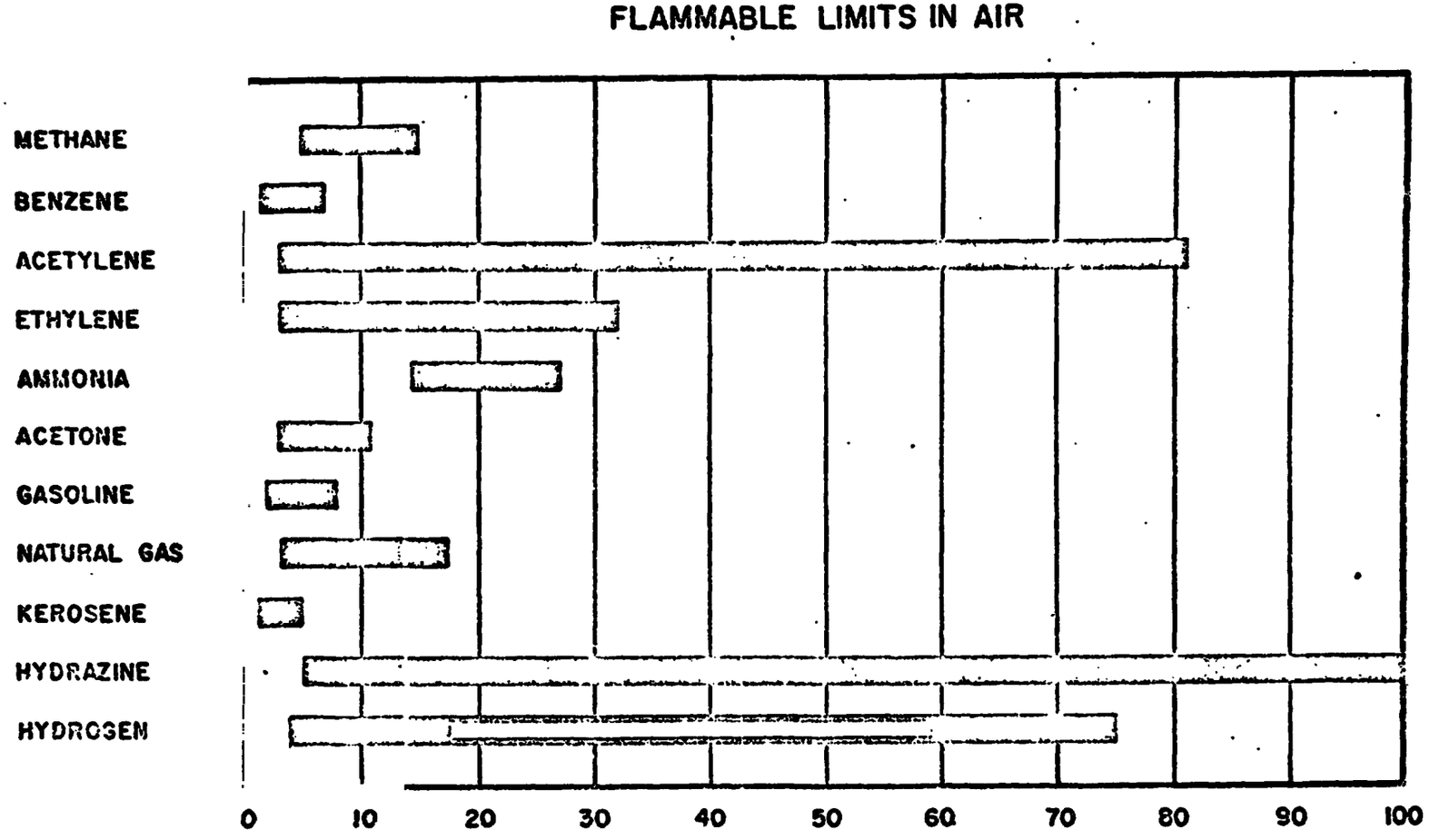


Figure 8 Volume Percent Concentration in Air

Reference: Himmelberger, F., "Liquid Hydrogen Safety" presented at Air Products, Incorporated Safety Symposium, July, 1959.

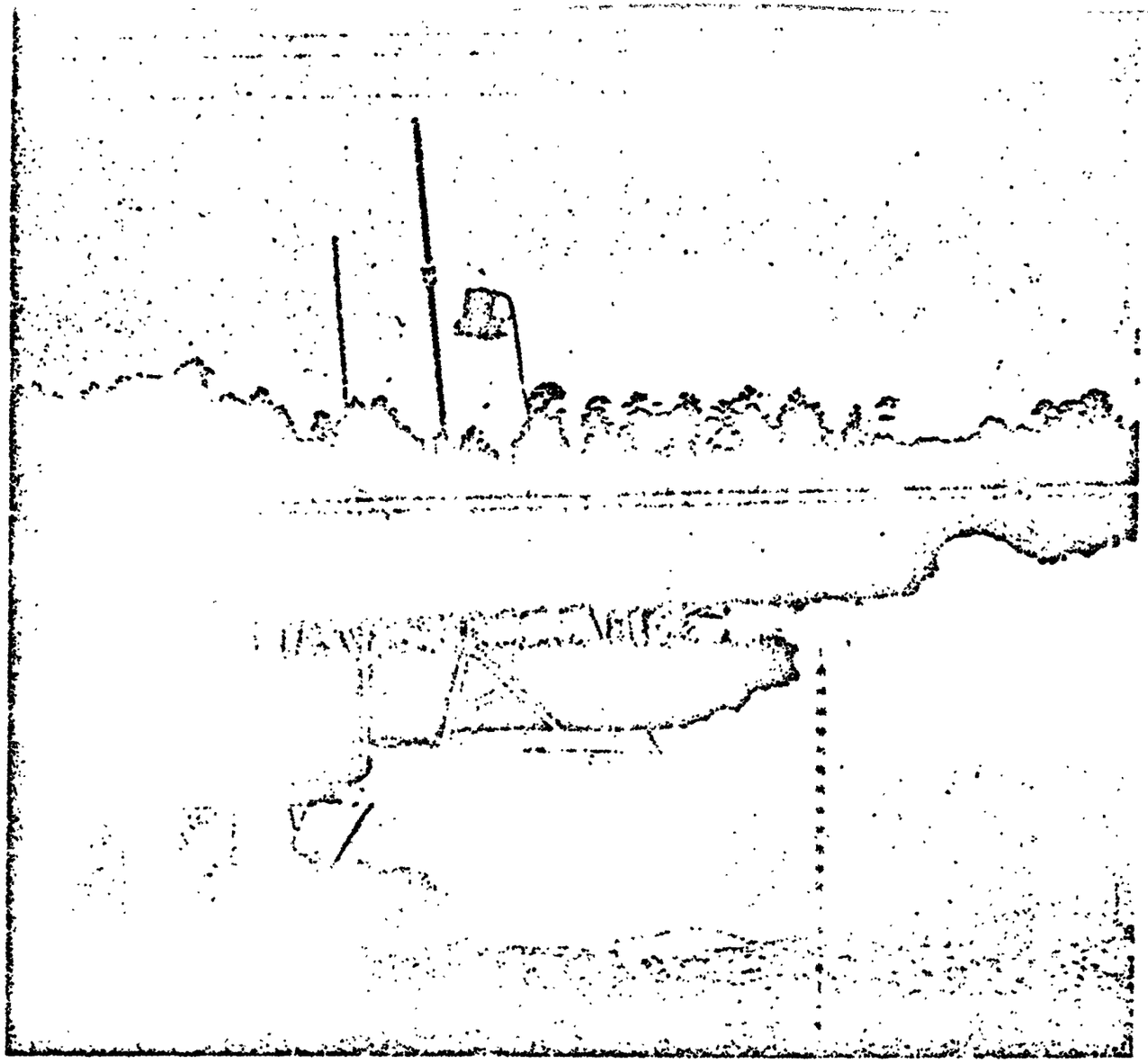


Figure 9

Spill Test of Liquid Hydrogen simulating a Broken Line.

Courtesy Air Products, Incorporated

AIR PRODUCTS AND CHEMICALS, INC.

PUT IT IN WRITING

DATE May 23, 1968

TO E. J. Donley

SUBJECT LOX Spill. NCG - Conshohocken

FROM W. L. Ball

cc:
J. H. Arnold
D. F. Baker
C. S. Block
W. L. Ent
W. H. Halsted
A. L. Hatley
M. H. Hubbs
L. R. Mann
H. H. Master
C. B. McSwain
A. W. Mellen
P. F. Newman
W. T. Rector
W. M. Say
W. J. Scharle
J. K. Stewart
H. E. Wynn

APL
I. Everson
G. Fedorko
J. Hamilton
A. L. Kerridge
J. Hamilton

This memo is to summarize the information obtained from several telephone conversations with William Arner of NCG relative to the LOX spill at their Conshohocken facility. The incident occurred about 0430, 13 May 1968, and resulted in spilling the liquid equivalent of 28 million standard cubic feet of gas (1160 tons of liquid).

The double wall, spherical storage tank was built by Graver and put into service in January 1968.

Inner Tank	- aluminum
Outer Shell	- carbon steel
Insulation	- perlite in annular space
Discharge Piping	- 4" aluminum in annular space with transition to copper for line to pump suction

The tank design specified the discharge pipe in the annular space to be a continuous bent piece without welds. It is reported, however, that apparently due to dimensional error the piece was too short and a section about 18 inches long was welded on the end. When the line was installed, this weld was in the end of the "pant leg" or sleeve thru which the line penetrates the outer shell, and about 18 inches from the transition joint to the copper transmission line. It was also reported that the weld had been ground flat to blend in with the outer wall of the pipe, which may have created some thin spots. As this weld was on the warm side of the gas trap in the line, it had been thermal-cycled repeatedly in the normal operation of the tank.

When this weld failed, some liquid exited from the tank thru cracks in the outer shell and "pant leg", but most of the liquid collected in the bottom of the annular space until a section of the outer shell cracked and fell out. This dumped the perlite and the liquid on the ground under the tank. A 4 inch stream of LOX was

APCI DOCUMENT NO 12000320

described as jetting about 10 feet beyond the circumference of the tank onto a concrete driveway. The break was on the side of the tank away from the process equipment and building, and the elevation under the tank was described as being slightly higher than the surrounding area. The liquid flowed away from the tank into the tanker loading area, into the truck seals pit (collapsing the platform), into an unpaved parking area where three tankers were parked, and over a bank away from the plant.

Fire hoses and water spray were used to control, as far as possible, flow of liquid on the ground and to evaporate the liquid as fast as possible. This activity was hampered to a marked degree by 4 to 6 foot drifts of perlite which covered the liquid pools and restricted evaporation. There apparently were some small pools of LOX under the perlite as late as Wednesday. The three tankers were surrounded by liquid but there was no damage other than cracking of the tires. These units were not moved for three days as there was concern that the LOX might have seeped into the ground. This area was unpaved fill but was relatively dense, containing a fair percent of clay. Moving the trailers was delayed until all evidence of liquid and vapor was gone.

The vapor cloud was quite extensive but, as the facility is relatively isolated, did not cause extensive community disruption. One local street was blocked off temporarily. Analysis was made for high oxygen content, with 24% oxygen being reported on the edge of the cloud. The operating plant was shut down part of the first day. The weather was bad for this type of incident as at the time of failure it was "dead still with a slight ground fog". Dispersion of the vapor was relatively slow and the weather would tend to create high concentrations in the area of the spill.

NCG feels this was a "freak accident" relating directly to a deviation from design specifications and the hidden weld. They reportedly are now contemplating x-ray of all welds connecting to the liquid phase of a tank, and also etching along the axis of the pipe to detect hidden welds.

NCG has experienced at least two failures of aluminum welds in their boxes on liquid lines. In one incident at their Sharon plant the failure was in the "oxygen make line" and resulted in dumping the condenser liquid into the cold box. This resulted in over pressuring and bulging the jacket, but no liquid spilled from the box.

Original Signed By

W. L. Ball

WLB:dt

Re-typed May 31, 1972
kfq

Air Products and Chemicals, Inc.

Date July 22, 1971

INTER-OFFICE MEMORANDUM

Subject: Discussion with Mr. E. Lucas, IPD Inspection, Regarding APCI Cleanliness Requirements

To File

(Location, Organization, or Department)

From A. Lapin

(Location, Organization, or Department)

cc: W. L. Ball
F. K. Kitson
E. Lucas
W. M. McCormick
C. McKinley
E. J. Tyminski

I met with Mr. Lucas on July 21st to review the exact inspection steps taken in conjunction with QCL 106F APCI Class AA Cleanliness Requirements, QCL 107F APCI Class AAA Cleanliness Requirements. Mr. Lucas emphatically stated that the APCI inspectors are quite thorough in their examination of material to determine whether they meet QCL 106F or QCL 107F. The following specific points were made:

1. If the surface is accessible, then the inspectors usually perform the visual examination under strong white light, ultra-violet light, and wipe test. The wipe test is usually performed with a Whatman filter paper or with white nylon lint-free cloth. This is probably the most important test to determine cleanliness of the surface. Mr. Lucas felt that these three inspection steps will provide proper inspection to determine compliance with Class AA Cleanliness Requirements.

2. Flushing tests for accessible surface is very seldom performed.

3. Flushing is usually performed for inaccessible surfaces using methylene chloride as a solvent. About 4 ounces of the spent solvent will be examined for appearance and then filtered through a millipore filter. Examination will then be made of the particle population, and a count will be made to determine that there are no particles larger than 1,000 microns and no more than 10 particles between 500 and 1,000 microns. There are no restrictions on the number of particles smaller than 500 microns.

4. For Class AAA Cleanliness Requirements, the flushing with methylene chloride will be performed and the solvent then filtered through a millipore filter. In this case, slight discoloration of the filter will be cause for rejection. Mr. Lucas believed that this requirement was a major difference between Class AA and Class AAA Cleanliness Requirements.

   Mr. Lucas did not think that piping could be cleaned to Class AAA requirements because it would not pass the millipore discoloration criterion.

APCI DOCUMENT NO. 22000-121

5. In general, the inspectors will discuss the reason for rejection with the Shop forman. However, the only records kept are those of final acceptance. Records of rejection are not kept.

6. Packaging and sealing of the cleaned parts are usually done immediately following the inspection. It is the inspectors responsibility to ensure that this is done.

7. Mr. Lucas felt that the QCL's should allow the inspector to use his judgment regarding the need of flushing of an accessible surface. He believed that the inspection using the wipe test could establish cleanliness of the surface without needing the flushing test. He also pointed out that under certain conditions, it would not be practical to carry out the required flushing test such as with each tray in a distillation column.

ak

AL:plr

LB

Air Products and Chemicals INC.

Date July 22, 1971

INTER-OFFICE MEMORANDUM

Subject Telephone Conversation with Mr. William McCormick Re Requirements for Vendor Class AA and Class AAA Cleaning

To File

(Location, Organization, or Department)

From A. Lapin

(Location, Organization, or Department)

cc: W. L. Ball
F. K. Kitson
E. Lucas
W. M. McCormick
C. McKinley
E. J. Tyminski

Following my discussion with Mr. E. Lucas, I called Mr. McCormick, Quality Control Department, to check on our inspection procedures covering purchased material. Mr. McCormick stated that a number of vendors can meet our QCL 117F requirement for Class AAA cleaning, while others cannot meet even QCL 115F for Class A cleaning. He pointed out, however, that those vendors who cannot meet our cleaning requirements in their shop are required to have the cleaning done elsewhere, and that our inspection is then carried out in the plant where cleaning is done. In general, all the requirements of our Quality Control Layouts are met, including millipore testing for Class AAA cleaning.

AL:plr

APCI DOCUMENT NO. 99.000.222

QUALITY CONTROL PROGRAM

INDEX TO CONTENTS

Par. 1....Purpose
Par. 2....Scope
Par. 3....General
Par. 4....Instrumentation
Par. 5....Daily Operational Requirements
Par. 6....Cylinder Sampling
Par. 7....Cryogenic Sampling
Par. 8....Associated Forms and Tags
Par. 9....Exhibits

1. PURPOSE

The purpose of the Quality Control Program is to improve and upgrade the quality of industrial and medical gases produced and marketed by the Industrial Gas Division. In addition, the program may serve as a check on districts for adherence to good operational practices and will provide data for determining the accuracy of the district's quality assurance instrumentation.

2. SCOPE

This specification shall be jurisdictive as applicable to all districts unless specifically excluded by the Chief Engineer, I.G.D. or the IGD Technical Director's Department.

3. GENERAL

This specification provides the procedure and associated requirements necessary to assure compliance to established product quality specification by means of instrumentation control, sampling, and analysis of facility product.

3.1 Several men in each district shall be made available for work on the Quality Control Program. It would be desirable to have a minimum of two (2) operators and the Plant Superintendent familiar with the operation and maintenance of the facility's quality control instrumentation, and the sampling procedures. This should provide sufficient personnel to compensate for vacations, transfers, etc.

3.2 No work orders are required from the facility to cover the cost of sampling, analysis, maintenance of instrumentation, and sample shipment. All costs of the program are to be charged to a project order issued within the Industrial Gas Division. Designation of charges is to be made only by the Facilities Operations Manager and not by district personnel.

APCI DOCUMENT NO. 99000423

QUALITY CONTROL PROGRAM

3.3 Samples not normally covered under the Quality Control Program should show who requested such samples be taken. This should be recorded in the space provided under the remarks section of I & M Tag No. BST-1 (Exhibit D). This information is required for determining if the sample and analysis costs are already covered under the program.

4. INSTRUMENTATION

One (1) man at each facility should be assigned to perform daily instrument maintenance. When an operator suspects an instrument malfunction, he shall advise the Plant Superintendent or the Instrument Maintenance Operator. Problems regarding instrumentation maintenance, repair or recalibration which cannot be resolved locally will be referred to the Facilities Operations Manager, or the I.G.D. Senior Laboratory Technician charged with implementing the Quality Control Program.

4.1 Instrument maintenance check lists are available in all districts. They shall be utilized by the Instrument Maintenance Operator, and be kept on file for instrument evaluation.

4.2 The name of each Instrument Maintenance Operator in every plant shall be kept on file with the Facilities Operations Manager and the Senior Laboratory Technician.

5. DAILY OPERATIONAL REQUIREMENTS

Facility product in containers for delivery to customer(s) must be sampled and analyzed in order to assure compliance to established I & M purity specification (Section 10 of the District Operations Manual). Sampling and analysis will be performed as follows:

a. Tube Trailers: Each tube trailer filled will be sampled and analyzed.

b. Tank Trailers: A representative sample of the contents of each trailer filled will be analyzed.

c. Cylinders: Once daily, one (1) cylinder chosen at random from filled cylinders of each charging manifold used, shall be sampled and analyzed.

5.1 The purity checks required by the above will be conducted on the facility's analyzers, and the results of the analysis will be recorded on I & M Form 3096, Rev. 3 (Exhibit A).

QUALITY CONTROL PROGRAM

5.2 The I G D Reporting Form 3096, Rev. 3 (Exhibit A) will be filled out in duplicate. One (1) copy will be retained at the district office, the other copy will be forwarded to the Facilities Operations Manager, Industrial Gas Division at Allentown, Pennsylvania. Accumulated forms will be transmitted during the first week of each month.

5.3 NOTE: The sampling requirements listed herein shall not eliminate nor take the place of the product sampling required by the filling procedures (Sections 3.2.1.1, 3.2.1.2, 3.2.1.3, 3.2.1.4, and 3.2.1.5 of the District Operations Manual).

6. CYLINDER SAMPLING

Once every two (2) months, each district will be required to submit one (1) full cylinder of each product filled at the district, to the "I.G.D." Quality Control Laboratory for complete analysis.

NOTE: EXCEPTIONS

(a) "All Products"....
The sample frequency rate shall be increased to a monthly basis in cases where product specifications or customer requirements necessitate contaminant analyses which exceed the capability of the district's analysis equipment.

Certain customer specifications will automatically require an increase in the sample frequency rate as necessary for compliance to customer requirements.

(b) "Oxygen"....
The sample frequency rate may be reduced to one (1) full cylinder per district once every three (3) months, unless the district is filling cylinders or tube-trailers for use as breathing-oxygen, in accordance with military specifications, or unless more frequent sampling is required by the conditions described by (a) above.

6.1 Cylinder(s) for analysis should be selected at random from the full cylinder product storage area. Such cylinder(s) shall be analyzed by use of the facility's instrumentation prior to shipment of cylinders to the I G D Laboratory. The results of the facility analysis shall be recorded on I G D Form 3096, Rev. 3 (Exhibit A).

REPRODUCIBILITY OF THE ORIGINAL COPY IS POOR.

QUALITY CONTROL PROGRAM

6.2 Cylinder(s) for I.G.D. Laboratory analysis shall be shipped "collect" motor freight to:

AIR PRODUCTS AND CHEMICALS, INC.
Plant No. 1 Attn: I.G.D. Quality Control
733 West Broad Street
Emmaus, Pennsylvania

6.2.1 A bill of lading must be prepared by the facility for each shipment. See sample bill of lading (Exhibit C2) for details, if required. In addition, an I G D Tag, Form 412 (Green or Red Tag, as applicable), must be filled out and attached to each cylinder in a secure manner. The 412 tag shall list the name of the gas contained in the cylinder.

a. Under no circumstance shall cylinder(s) be shipped by Air Products and Chemicals, Inc. trucks.

b. Cylinders will be returned to districts after product analysis via "pre-paid" motor freight.

6.3 It will also be necessary to identify the cylinders when processed by the I.G.D. Quality Control Laboratory. Tag Form BST-1 (Exhibit D) is provided for this purpose. It will be filled out completely at the facility and attached to the cylinder at the base of the cylinder valve.

7. CRYOGENIC SAMPLING

Once every four (4) months, a cryogenic sample will be collected from each storage tank for each cryogenic product handled at the district. Districts will automatically procure and forward such sample(s) to "I.G.D." Quality Control Laboratory for complete analysis. The districts are provided with APCI Batch Samplers for this purpose.

NOTE: EXCEPTIONS

(a) "All Cryogenic Products"....
The sample frequency rate shall be increased to one sample per two month period for districts where product specifications or customer requirements necessitate contaminant analyses which exceed the capability of the districts analysis equipment.

Certain customer specifications may automatically require an increase in the sample frequency rate as necessary for compliance to customer requirements.

(b) "Liquid Plants"...
Plants designed primarily for liquid production and not having compression facilities (Example: Ashland, Delaware City, etc.) shall submit product samples for analysis on a monthly basis.

(c) "Oxygen" (LOX)
The sample frequency rate may be reduced to one cryogenic sample per tank once every six (6) months unless the district is supplying product for breathing purposes, in accordance with military specifications, or unless more frequent sampling is required by the conditions described in (a) and (b) above.

7.1 Filled batch samplers shall be shipped "prepaid" motor freight to:

Air Products and Chemicals, Inc.
733 West Broad Street
Emmaus, Penna.
Attention: IGD Quality Control

Emergency shipments of samples via air-freight are permitted by cargo-carrying aircraft only.

a. The Airbill/Airwaybill must contain the same description as shown on the sample Bill of Lading (Exhibit C1) and further by inserting the word "gaseous" after the product name.

b. Samplers offered for shipment by air must be accompanied by two (2) copies of the Shipper's Certification (Exhibit E).

c. The Airbill/Airwaybill must contain the statement "cargo-carrying aircraft only."

7.2 A Bill of Lading must be prepared by the facility for each shipment.

See sample Bill of Lading (Exhibit C1) for the only proper description to use.

a. The form 412 tag shall list the name of the gas contained by the sampler. Space is provided on the tag.

b. DOT (Dept. of Transportation) Special Permit #3302 shall be used for batch samplers only.

c. Under no circumstances shall samples be shipped via Air Products and Chemicals, Inc., trucks.

d. The batch samplers will be returned to districts via "collect" motor freight.

QUALITY CONTROL PROGRAM

7.3 It will also be necessary to identify the samples when processed by the I.G.D. Laboratory. Tag Form BST-1 (Exhibit D) is provided for this purpose. The tag shall be filled out in detail at the facility and securely attached inside the batch sampler case.

8. FORMS AND TAGS

8.1 The forms and tags required for use by this specification are listed below. They can be obtained from the sources listed.

a. Form 3096, Rev. 3 and form #3330: Order directly from APCI Stationery Stores, Allentown, Pennsylvania.

b. Straight Bill of Lading (Exhibit C-1 and C-2): APCI Form No. 3102, order from APCI Stationery Stores, Allentown, Pennsylvania.

c. BST-1 Tag: (APCI Material Code No. 4-847-51-0018). Order directly from APCI Spare Parts Department, Allentown, Pennsylvania.

d. Form 412-G and 412-R Tags: (APCI Material Code No. 4-847-51-0012 - Green Tag; 4-847-51-0013 - Red Tag). Order directly from APCI Spare Parts Department, Allentown, Pennsylvania.

9. EXHIBITS

The following pages depict the forms and tags required in implementing the Quality Control Program. (Some of the forms are filled-out to provide an example for the user.)

EXHIBIT A

PRODUCT ANALYSIS: FORM 3096

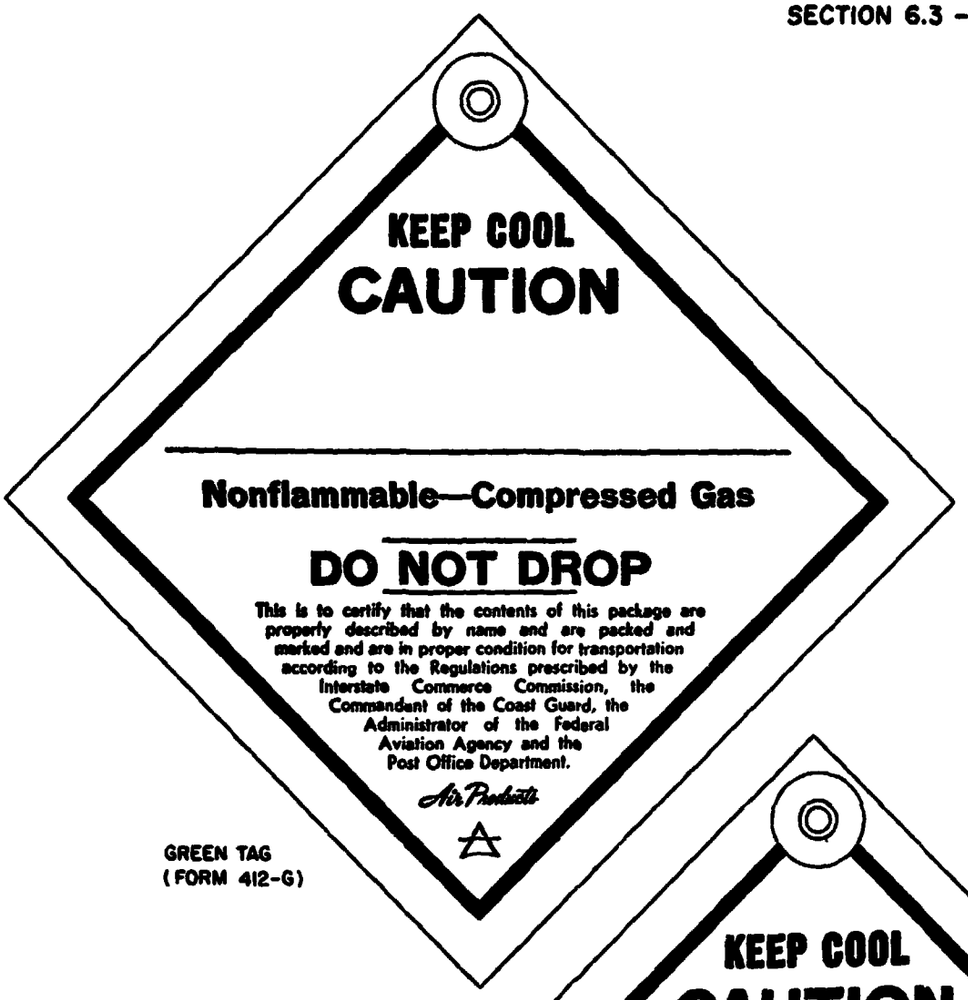
Air Products and Chemicals INC.
INDUSTRIAL GAS DIVISION

Facility _____
Product _____
Month _____

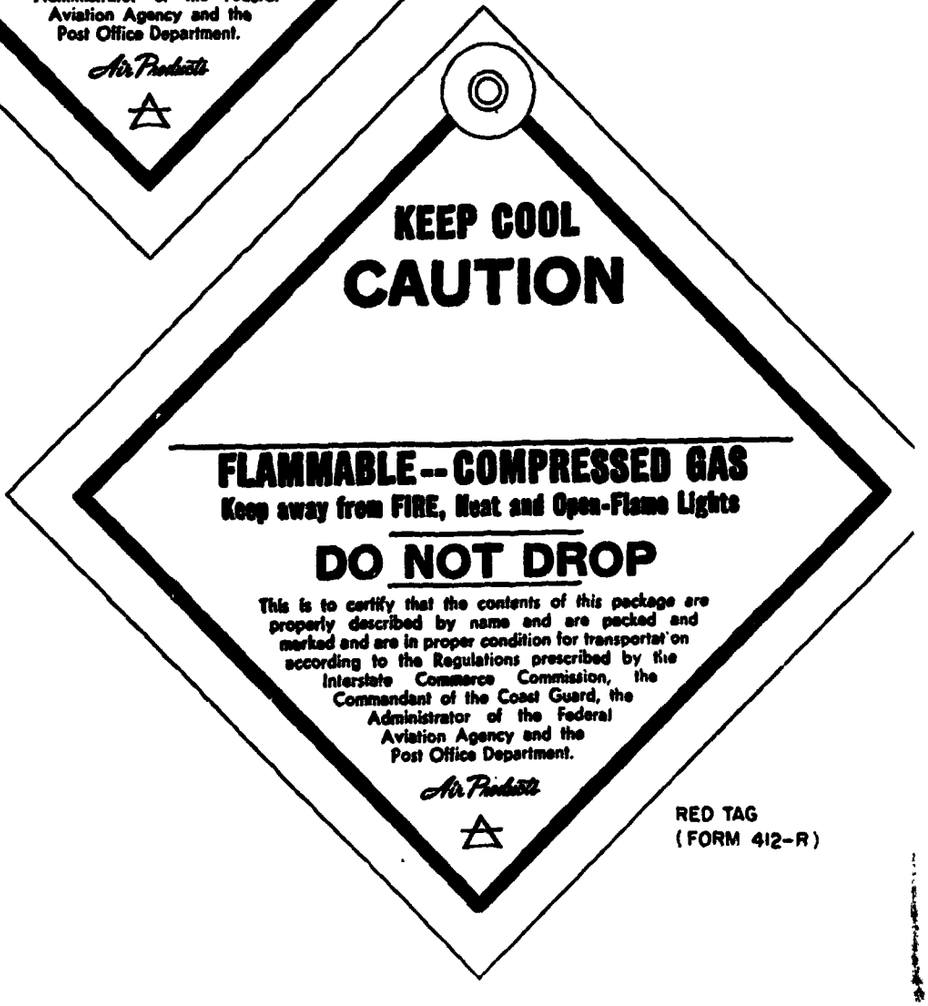
PRODUCT ANALYSIS: This form will be used by districts in reporting the results of daily analysis as required by IGD Filling Procedures (Section 3), Quality Control Program (Section 6.3), and Loading Procedure (Section 9.1) of the Volume 1 IGD District Operations Manual.

DATE	CYL. TANKER, OR TRAILER NUMBER	PRESS. PSIG	PURITY MOL %	OXYGEN PPM	DEW POINT	LOT NUMBER IF APPLICABLE	OPERATOR AND REMARKS

EXHIBIT "B"



GREEN TAG
(FORM 412-G)



RED TAG
(FORM 412-R)

EXHIBIT C1

STRAIGHT BILL OF LADING—"SHORT" FORM

FOR USE EITHER BY RAIL OR MOTOR CARRIER

ORIGINAL
NOT NEGOTIABLE

1

RECEIVED, subject to the classifications and tariffs in effect on the date of the issue of this Bill of Lading,

from **AIR PRODUCTS AND CHEMICALS, INC.**

the property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated below, which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the terms and conditions of the Uniform Domestic Straight Bill of Lading set forth (1) in Official, Southern, Western and Illinois Freight Classifications in effect on the date hereof, if this is a rail or a rail-water shipment, or (2) in the applicable motor carrier classification or tariff if this is a motor carrier shipment.

Shipper hereby certifies that he is familiar with all the terms and conditions of the said bill of lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation of this shipment, and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

SAMPLE

At ...Name of facility e.g. Creighton, Pa.... March 28 ...19 68... Shipper's No. .....

By ...Name of Carrier..... (Name of Carrier) Agent's No. .....

Consigned to ...Air Products and Chemicals, Inc..... (Mail or street address of consignee—For purposes of notification only.)

Destination ...Emmaus..... State ...Pennsylvania... County ...Lehigh.....

Delivery Address ...733 West Broad St., Attention: ICD Quality Control.. (To be filled in only when shipper desires and governing tariffs provide for delivery thereof.)

Route .....

Delivering Carrier ..... Car or Vehicle Initials ..... No. .....

No. Packages	Kind of Package, Description of Articles, Special Marks, and Exceptions	*Weight (Subject to Correction)	Class or Rate	Check Column
1	Oxygen, non-flammable compressed gas, in	50		
	steel cylinder (Batch sampler)			
1	Nitrogen, non-flammable compressed gas,	50		
	in steel cylinder (Batch sampler)			
1	Argon, non-flammable compressed gas, in	50		
	steel cylinder, (Batch sampler)			
	DOT Special Permit #3302			
	Total	150		

Subject to Section 7 of Conditions of applicable bill of lading, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:

The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

.....
(Signature of consignor.)

If charges are to be prepaid, write or stamp here, "To be Prepaid."

To Be Prepaid

Received $.....
to apply in prepayment of the charges on the property described hereon.

.....
Agent or Cashier.

Per .....
(The signature here acknowledges only the amount prepaid.)

Charges advanced:

$ .....

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is carrier's or shipper's weight.

Note.—Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.

The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding ..... per .....

THIS IS TO CERTIFY THAT THE ABOVE NAMED ARTICLES ARE PROPERLY CLASSIFIED, DESCRIBED, PACKAGED, MARKED, AND LABELED, AND ARE IN PROPER CONDITION FOR TRANSPORTATION, ACCORDING TO THE APPLICABLE REGULATIONS OF THE DEPARTMENT OF TRANSPORTATION.

AIR PRODUCTS AND CHEMICALS, INC. Shipper. ..... Agent.

Per (Shipper's Signature)..... Per.....

Permanent post office address of shipper P.O. [illegible], ALLENTOWN, PA. — Attn. Distribution Dept.

Form 3102 6/68

The above bonds used for this shipment conform to the specifications set forth in the box maker's certificate thereon, and all other requirements of Rule 41 of the consolidated freight classification.

SAMPLE

Form 3102 as depicted here is not actual size.

THIS MEMORANDUM

is an acknowledgment that a Bill of Lading has been issued and is not the Original Bill of Lading, nor a copy or duplicate, covering the property named herein, and is intended solely for filing or record.

1

RECEIVED, subject to the classifications and tariffs in effect on the date of the issue of this Bill of Lading,

from AIR PRODUCTS AND CHEMICALS, INC.

the property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned and destined as indicated below, which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is [illegible] agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the terms and conditions of the Uniform Domestic Straight Bill of Lading set forth (1) in Official, Southern, Western and Illinois Freight Classifications in effect on the date hereof, if this is a rail or a rail-water shipment, or (2) in the applicable motor carrier classification or tariff if this is a motor carrier shipment.

Shipper hereby certifies that he is familiar with all the terms and conditions of the said bill of lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation of this shipment, and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

SAMPLE

At Name of facility e. g. Creighton, Pa. March 28 19 68 Shipper's No. ...

By Name of Carrier (Name of Carrier) Agent's No. ...

Consigned to Air Products and Chemicals, Inc. (Mail or street address of consignee—For purposes of notification only)

Destination Emmaus, State Pennsylvania County Lehigh

Delivery Address 733 West Broad St., Attn: IGD Quality Control (To be filled in only when shipper desires and governing tariffs provide for delivery thereat)

Route ...

Delivering Carrier ... Car or Vehicle Initials ... No. ...

No. Packages	Kind of Package, Description of Articles, Special Marks, and Exceptions	*Weight (Subject to Correction)	Class or Rate	Check Column
1	Oxygen, nonflammable compressed gas, in steel cylinder	50		
1	Nitrogen, non-flammable compressed gas, in steel cylinder	50		
1	Argon, non-flammable compressed gas, in steel cylinder	50		
	Total	150#		

SAMPLE

DISTRICT OPERATIONS MANUAL

SECTION 6.3 - Quality Control Program

EXHIBIT G-2

Apr/68
Rev.2

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is carrier's or shipper's weight.

Note.—Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.

The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding ... per ...

THIS IS TO CERTIFY THAT THE ABOVE NAMED ARTICLES ARE PROPERLY DESCRIBED, AND ARE PACKED AND MARKED AND ARE IN PROPER CONDITION FOR TRANSPORTATION ACCORDING TO THE REGULATIONS PRESCRIBED BY THE INTERSTATE COMMERCE COMMISSION AND/OR THE COMMANDANT OF THE U. S. COAST GUARD AND/OR THE CIVIL AIR REGULATION.

Subject to Section 7 of Conditions of applicable bill of lading, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement: The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

SAMPLE

(Signature of consignor.)

If charges are to be prepaid, write or stamp here, "To be Prepaid."

To Be Prepaid

Received $ ...
to apply in prepayment of charges on the property described hereon.

Agent or Cashier.

Per ...
(The signature here acknowledges only the amount prepaid.)

Charges advanced:

$ ...

AIR PRODUCTS AND CHEMICALS, INC. Shipper. ... Agent

Per (Shipper's Signature) Per ...

Permanent post office address of shipper P.O. BOX 538, ALLENTOWN, PA. — Attn. Distribution Dept.

Form No. 3102- -Printed in U.S.A.

Use fibre boxes used for this shipment conform to the specifications set forth in the box maker's certificate thereon, and all other requirements of Rule 41 of the consolidated freight classification.

EXHIBIT "D"

Ship to:
AIR PRODUCTS AND CHEMICALS, INC.
Plant #1
733 W. Broad Street
Emmaus, Penna.

Attn: I & M QUALITY CONTROL

Air Products and Chemicals INC.

I & M Quality Control Sample

Product _____ Plt. Location _____

Sample Source _____ Pressure _____ Psig

(Plt. Valve & No., Storage Tank & No., Manifold, Etc.)

Sample Pressure _____ psig

(Final-pressure after Sample Vaporizes in Mod. 4 Sampler)

Cylinder Ser. No. _____ Batch Sampler Ser. No. _____

Sample Date _____ Sampled By _____

Remarks: _____

_____

FORM 887-1
Rev. 1

Air Products and Chemicals INC.

ALLENTOWN, PENNSYLVANIA

Date_____

SHIPPER'S CERTIFICATION FOR RESTRICTED ARTICLES

This is to certify that the contents of this consignment are properly described by name and are packed, marked and labeled and are in proper condition for carriage by air according to all applicable carrier and governmental regulations. This consignment is within the limitations prescribed for passenger/cargo (cross-out one) carrying aircraft.

MARKS AND NUMBERS ON PACKAGES (OPTIONAL)	IATA ITEM NUMBER	SPECIFY EACH ARTICLE SEPARATELY (TRADE NAMES NOT PERMITTED (OPTIONAL)	NET QUANTITY PER PACKAGE (OPTIONAL)	LABEL REQUIRED

Air Products and Chemicals

PUT IT IN WRITING

Date May 10, 1968

To H. E. Lindenmoyer Subject Analyses Required on Quality Control Samples

From D. J. Scott

( ) Take Action ( ) For Your Approval ( ) For Your Info ( ) Discuss With Me

( ) For Your Comments ( ) As Requested ( ) File ( ) Note & Return

The following analyses are required:

Oxygen -

Argon
Oxygen
Nitrogen
Carbon Dioxide
Carbon Monoxide
Nitrous Oxide
Methane
Acetylene
Krypton
Total Hydrocarbons

Argon -

Argon
Oxygen
Nitrogen
Helium
Hydrogen
Carbon Dioxide
Carbon Monoxide
Methane
Total Hydrocarbons

Nitrogen -

Argon
Oxygen
Nitrogen
Hydrogen
Carbon Monoxide
Neon
Total Hydrocarbons

Hydrogen -

Oxygen
Nitrogen
Hydrogen
Carbon Dioxide
Carbon Monoxide
Nitrous Oxide
Methane
Chlorides
Total Hydrocarbons

Helium -

Argon
Oxygen
Nitrogen
Helium
Carbon Dioxide
Methane
Total Hydrocarbons

In addition, a water analysis is required on all cylinders and please report any additional contaminants which appear on the Infrared Spectra.

D. J. Scott

DJS:amf

Retyped June 2, 1972
kfq

FORM 5727

APCI DOCUMENT NO 99000324

Air Products and Chemicals INC.
INDUSTRIAL GAS DIVISION

I. G. D.
DISTRICT OPERATIONS MANUAL
VOLUME IV
I.P.M.D. No. 0101

PUT IT IN WRITING

Date 10/17/66

To ALL HOLDERS OF DISTRICT OPERATIONS MANUALS

Subject Revisions to IGD Quality Assurance Program Cost Procedures (Section 6.3 - District Operations Manual)

From W. L. Eat

cc: L. C. Kemmerer
P. F. Newman

In order to reduce the accounting time and costs involved in the Quality Assurance Program, the following changes shall be made in the cost allocation procedures: (These procedures supersede those of Section 6.3 in the District Operations Manual.)

1. Each District will automatically be assessed a fixed monthly charge to cover both routine and non-routine analyses performed by the Specialty Gases Laboratory. These monthly charges for each District are listed in the accompanying attachment. All Districts will be charged with their respective amounts whether the required number of samples is submitted for anlaysis or not.

   a. The required routine sample schedules for each District are given in the attachment. Samples should be sent to the Specialty Gases Laboratory in Emmaus, Pa., in compliance with the schedule.

   b. Also, the fixed monthly charge includes a prorated amount to cover non-routine analyses performed by the Laboratory. This amount is prorated to the respective Districts in accordance with the total number of routine samples per District.

2. The individual Districts shall directly assume the shipping costs for sample cylinders. Samples sent to the Specialty Gases Laboratory should be sent with shipping costs Prepaid by the District. After analysis, the sample cylinders will be returned to the District "Freight Collect". In the past these charges were accumulated by Accounting and charged to the Districts at a later time.

The Technical Services and Maintenance phases of the Quality Assurance Program will, as in the past, be charged to the Districts after service is provided.

In addition to the above costing procedure changes, we are still receiving many sample cylinders with incompletely and/or improperly filled in labels. Please be sure that all labels are completely and properly filled in prior

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Air Products and Chemicals INC.
INDUSTRIAL GAS DIVISION

I. G. D.
DISTRICT OPERATIONS MANUAL
VOLUME IV
I.P.M.D. No. 0101

to shipping. This procedure was discussed at the Operations Symposia and is covered in the District Operations Manual.

Your cooperation on these matters will be appreciated.

W. L. Ent
Facilities Operations Manager
Industrial Gas Division

TKB/WLE/me

Attachment

SCHEDULE FOR SU[illegible] ROUTINE PRODUCT SAMPLES

DISTRICT/ SUFFIX NO.		PRODUCT	GAS SAMPLE FREQUENCY	LIQUID SAMPLE FREQUENCY	AVG. SAMPLES PER MONTH
Albany	02	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	2.5
		Argon	ea. 2 mos.	ea. 2 mos.)	
Allegheny	04	Oxygen	ea. 4 mos.	ea. 1 mo.)	
		Nitrogen	ea. 2 mos.	ea. 1 mo.)	4.7
		Argon	ea. 2 mos.	ea. 1 mo.)	
		Helium	ea. 2 mos.	—)	
Ashland	05	Oxygen	—	ea. 1 mo.)	
		Nitrogen	—	ea. 1 mo.)	2.0
Atlanta	06	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	1.5
Bladensburg	07	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
		Argon	ea. 2 mos.	ea. 2 mos.)	3.5
		Helium	ea. 2 mos.	—)	
Bloomfield	08	Oxygen	—	ea. 4 mos.)	
		Nitrogen	—	ea. 2 mos.)	1.75
		Argon	—	ea. 2 mos.)	
		Hydrogen	ea. 2 mos.	—)	
Burns Harbor	09	Oxygen	—	ea. 1 mo.)	
		Nitrogen	—	ea. 1 mo.)	2.0
Chicago	11	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	2.75
		Argon	ea. 2 mos.	ea. 2 mos.)	
Chocolate Bayou	12	Nitrogen	—	ea. 1 mo.)	1.0
Cleveland	13	Oxygen	ea. 4 mos.	ea. 2 mos.)	
		Nitrogen	ea. 2 mos.	ea. 1 mo.)	3.75
		Argon	ea. 2 mos.	ea. 1 mo.)	
Dallas	17	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	3.0
		Argon	ea. 2 mos.	ea. 2 mos.)	
		Hydrogen	ea. 2 mos.	—)	
Delaware City	18	Oxygen	—	ea. 1 mo.)	
		Nitrogen	--	ea. 1 mo.)	3.0
		Hydrogen	ea. 1 mo.	—)	

SCHEDULE FOR SUBMITTING ROUTINE PRODUCT SAMPLES

PAGE TWO

DISTRICT/ SUFFIX NO.		PRODUCT	GAS SAMPLE FREQUENCY	LIQUID SAMPLE FREQUENY	AVG. SAMPLES PER MONTH
Edgewood	21	Hydrogen	ea. 1 mo.	—)	1.0
Greensboro	32	Oxygen	ea. 4 mos.	ea. 4 mos.)	1.75
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
Hampton	35	Oxygen	ea. 4 mos.	ea. 4 mos.)	2.5
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
		Argon	ea. 2 mos.	ea. 2 mos.)	
Hopewell	37	Hydrogen	ea. 1 mo.	—)	1.0
Iselin	43	Oxygen	ea. 4 mos.	ea. 4 mos.)	2.5
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
		Argon	ea. 2 mos.	ea. 2 mos.)	
Jacksonville	45	Oxygen	ea. 4 mos.	ea. 4 mos.)	1.5
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
Kansas City	50	Oxygen	ea. 4 mos.	ea. 4 mos.)	2.0
		Argon	ea. 2 mos.	ea. 2 mos.)	
		Helium	ea. 2 mos.	—)	
Kingsport	52	Oxygen	ea. 4 mos.	ea. 4 mos.)	2.5
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
		Argon	ea. 2 mos.	ea. 2 mos.)	
Lathrop	54	Oxygen	—	ea. 1 mo.)	2.0
		Nitrogen	—	ea. 1 mo.)	
Largo	55	Oxygen	ea. 4 mos.	ea. 4 mos.)	2.0
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
		Hydrogen	ea. 2 mos.	—)	
Lehigh	56	Oxygen	ea. 4 mos.	ea. 4 mos.)	1.5
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
Long Beach	57	Oxygen	ea. 4 mos.	ea. 4 mos.)	3.0
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
		Hydrogen	ea. 2 mos.	—)	
		Argon	ea. 2 mos.	ea. 2 mos.)	
Middletown	59	Oxygen	—	ea. 1 mo.)	2.0
		Nitrogen	—	ea. 1 mo.)	
Memphis	60	Oxygen	ea. 4 mos.	ea. 4 mos.)	3.0
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
		Argon	ea. 2 mos.	ea. 2 mos.)	
		Hydrogen	ea. 2 mos.	—)	
Miami	61	Oxygen	ea. 4 mos.	ea. 4 mos.)	0.5

SCHEDULE FOR SUBMITTING ROUTINE PRODUCT SAMPLES

PAGE THREE

DISTRICT/ SUFFIX NO.		PRODUCT	GAS SAMPLE FREQUENCY	LIQUID SAMPLE FREQUENCY	AVG. SAMPLES PER MONTH
Minneapolis	62	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	1.5
Mountain View	63	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
		Argon	ea. 2 mos.	ea. 2 mos.)	3.5
		Hydrogen	ea. 2 mos.	—)	
		Helium	ea. 2 mos.	—)	
Muscle Shoals	64	Hydrogen	ea. 1 mo.	—)	1.0
New Orleans	65	Oxygen	ea. 4 mos.	ea. 1 mo.)	
		Nitrogen	ea. 2 mos.	ea. 1 mo.)	3.25
		Hydrogen	ea. 2 mos.	—)	
Newark	66	Hydrogen	ea. 1 mo.	—)	1.0
Oklahoma City	67	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mo .)	1.5
Omaha	68	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	2.0
		Hydrogen	ea. 2 mos.	—)	
Painesville	70	Hydrogen	ea. 1 mo.	—)	1.0
Parkersburg	71	Oxygen	ea. 4 mos.	ea. 4 mos.)	0.5
Philadelphis	72	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	2.5
		Argon	ea. 2 mos.	ea. 2 mos.)	
Pittsburgh	73	Oxygen	—	ea. 1 mo.)	1.0
Rapid City	75	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	1.5
Boston	81	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	1.5
South Bend	82	Oxygen	ea. 4 mos.	ea. 4 mos.)	0.5
Sparrows Point	82	Oxygen	—	ea. 1 mo.)	2.0
		Nitrogen	—	ea. 1 mo.)	
St. Louis	84	Oxygen	ea. 4 mos.	ea. 4 mos.)	
		Nitrogen	ea. 2 mos.	ea. 2 mos.)	
		Argon	ea. 2 mos.	ea. 2 mos.)	3.5
		Hydrogen	ea. 2 mos.	—)	
		Helium	—	—)	
Weirton	96	Oxygen	—	ea. 1 mo.)	1.0

ANALYSIS REQUIREMENTS SUMMARY

INDEX TO CONTENTS

Par. 1.....Purpose
Par. 2.....Scope
Par. 3.....Analysis Requirements - Tube Trailers
Par. 4.....Analysis Requirements - Liquid Tankers and Railcars
Par. 5.....Analysis Requirements - Liquid Cylinders
Par. 6.....Analysis Requirements - Industrial Gas Cylinders
Par. 7.....Analysis Requirements - Medical Gas Cylinders
Par. 8.....Analysis Requirements - Environmental Mixtures
Par. 9.....Analysis Requirements - Purchased Product
Par. 10.....General Information

1. PURPOSE

To establish the frequency of analysis and the types of analytical equipment required for each Industrial Gas Division Product.

2. SCOPE

The material contained herein applies to all plants that fill or transfer Industrial Gas Division products unless the plant or product is specifically excluded by the IGD Manager of Procedures and Safety or the Specialty Gas Technical Manager.

3. ANALYSIS REQUIREMENTS - TUBE TRAILERS

Product	Sample	Analysis Required	Analytical Method	Special Considerations (Ref. par. 10)
Oxygen	Residual Contents	Total Purity (not normally required)	APCI Orsat or Paramagnetic	10.1, 10.3
		Moisture (not normally required)	Dew Pointer	10.1, 10.2
	Filled Trailer	Total Purity	APCI Orsat or Paramagnetic	10.3
		Moisture	Dew Pointer	10.2
Nitrogen	Residual Contents	Oxygen (not normally required)	Oxygen Trace	10.1, 10.6
		Moisture (not normally required)	Dew Pointer	10.1, 10.2

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Product	Sample	Analysis Required	Analytical Method	Special Considerations
Nitrogen	Filled Trailer	Oxygen Moisture	Oxygen Trace Dew Pointer	10.6 10.2
Argon	Residual Contents	Oxygen Moisture (not normally required)	Oxygen Trace Dew Pointer	10.6 10.1, 10.2
	Filled Trailer	Oxygen Nitrogen Moisture	Oxygen Trace Ion-Mobility Dew Pointer	10.6 10.7 10.2
Hydrogen	Residual Contents*	Oxygen Moisture (not normally required)	Oxygen Trace Dew Pointer	10.6 10.1, 10.2
	Filled Trailer*	Oxygen Moisture	Oxygen Trace Dew Pointer	10.6 10.2
Helium	Residual Contents	Oxygen Moisture (not normally required)	Oxygen Trace Dew Pointer	10.6 10.1, 10.2
	Filled Trailer	Oxygen Moisture	Oxygen Trace Dew Pointer	10.6, 10.8 10.2, 10.8

* Refer to Procedure No. 6.3.1-4 "Hydrogen Plant Sampling and Instrumentation" to determine additional analysis requirements for hydrogen tube trailers. The plant process will generally have a direct affect on the type and quantity of contaminents in the product hydrogen.

4. ANALYSIS REQUIREMENTS - LIQUID TANKERS AND RAILCARS

Product	Sample	Analysis Required	Analytical Method	Special Considerations (Ref. par. 10)
LOX	Residual Contents	Total Purity	Orsat	Sample taken from vapor phase, 10.3
	Filled Tanker and Railcar	Total Purity	Orsat	Sample taken from vapor phase, 10.3
	NOTE: Prior to unloading into APCI storage from other than APCI Production Facilities.	Total Purity	Orsat	Sample taken from vapor phase, 10.3

Product	Sample	Analysis Required	Analytical Method	Special Considerations
LIN	Residual Contents	Oxygen Content	Oxygen Trace	Liquid phase sample, 10.6
	Filled Tanker and Railcar	Oxygen Content	Oxygen Trace	Liquid phase sample, 10.6
	NOTE: Prior to unloading into APCI storage from other than APCI Production Facilities.	Oxygen Content	Oxygen Trace	Liquid phase sample, 10.6
LAR	Residual Contents	Oxygen	Oxygen Trace	Liquid phase sample, 10.6
	Filled Tanker and Railcar	Oxygen	Oxygen Trace	Liquid phase sample, 10.6
		Nitrogen	Ion-Mobility	Vapor phase sample
	NOTES:			
	a. Prior to unloading into APCI storage from other than APCI Production Facilities.	Oxygen	Oxygen Trace	Liquid phase sample, 10.6
		Nitrogen	Ion-Mobility	Vapor phase sample
	b. Prior to unloading into APCI storage from APCI Production Plant.	Nitrogen	Ion-Mobility	Vapor phase sample
LH_2	Residual	Oxygen	Oxygen Trace	Liquid phase sample, 10.6
	Filled Tanker and Railcar	Oxygen	Oxygen Trace	Liquid phase sample
	NOTE: Prior to unloading into APCI storage from other than APCI Production Facilities.	Oxygen	Oxygen Trace	Liquid phase sample

5. ANALYSIS REQUIREMENTS - LIQUID CYLINDERS (Does not apply to dewars)

Product	Sample	Analysis Required	Analytical Method	Special Considerations (Ref. par. 10)
LOX	Normally not required except any cylinder for inhalation use shall be analyzed.	Total Purity	Orsat	Vapor phase sample, 10.3

Product	Sample	Analysis Required	Analytical Method	Special Considerations (Ref. par. 10)
LIN	One cylinder per day except when customer use is determined to be for refrigeration purposes.	Oxygen	Oxygen Trace	Liquid phase sample, 10.6
LAR	Each cylinder filled	Oxygen	Oxygen Trace	Liquid phase sample, 10.6
L He	Each cylinder filled	Oxygen	Oxygen Trace	Liquid phase sample, 10.6

6. ANALYSIS REQUIREMENTS - INDUSTRIAL GAS CYLINDERS

Product	Sample	Analysis Required	Analytical Method	Special Considerations (Ref. par. 10)
Oxygen	1 cyl./shift	Total Purity	Orsat	10.5
	1 cyl./day	Moisture	Dew Pointer	10.2
High Purity Nitrogen	1 cyl./manifold	Oxygen	Oxygen Trace	
	1 cyl./day	Moisture	Dew Pointer	10.2
	LIN Storage Tank	Oxygen	Oxygen Trace (continuous when not in use analyzing cylinders)	Liquid phase, 10.6
Argon	1 cyl./manifold	Oxygen	Oxygen Trace	10.6
	1 cyl./manifold	Nitrogen	Ion-Mobility	10.7
	1 cyl./shift	Moisture	Dew Pointer	10.2
	LAR Storage Tank	Nitrogen	Ion-Mobility (continuous monitor when not in use analyzing cylinders)	Vapor phase
Helium	Source prior to filling and 1 cyl./manifold	Oxygen	Oxygen Trace	10.6
	Source prior to filling and 1 cyl./manifold	Moisture	Dew Pointer	10.2

Product	Sample	Required	Method	Special Considerations
Hydrogen	Source prior to filling and 1 cyl., manifold	Oxygen	Oxygen Trace	10.6
	Sourc prior to filling and 1 cyl./shift	Moisture	Dew Pointer	10.2
Industrial Gas Mixtures	1 cyl./manifold	One component must be analyzed (usually the minor component)	Thermal Conductivity Analyzer or Caustic Orsat	

7. ANALYSIS REQUIREMENTS - MEDICAL GAS CYLINDERS

Product	Sample	Analysis Required	Analytical Method	Special Considerations (Ref. par. 10)
Therapy & Medical Oxygen	1 cyl./manifold	Total Purity	Orsat or Paramagnetic	
Helium	1 cyl./manifold	Oxygen Content	Oxygen Trace	10.6
Carbon Dioxide				10.4
Cyclopropane				10.4
Ethylene				10.4
Nitrous Oxide				10.4
O_2/CO_2 Mixtures	Each cylinder	Carbon Dioxide	Thermal Conductivity or Caustic Orsat	10.4
	1 cyl./manifold	Oxygen	Orsat	
O_2/He	Each cylinder	Oxygen	Orsat, Paramagnetic, or Thermal Conductivity	
Compressed Air, Breathing Quality -				
By Reconstitution	Each cylinder	Oxygen	Orsat, Paramagnetic, or Polarographic	

Product	Sample	Analysis Required	Analytical Method	Special Considerations (Ref. par. 10)
By Compression of Atmospheric Air	1 cyl./manifold	Oxygen	Orsat, Paramagnetic, or Polarographic	10.10
Reciprocating Compressor	1 cyl./day	Moisture	Dew Pointer	10.10
Diaphragm Compressor	1 cyl./manifold	Moisture	Dew Pointer	10.10

8. ANALYSIS REQUIREMENTS - ENVIRONMENTAL MIXTURES (Diving Mixtures, etc.)

Product	Sample	Analysis Required	Analytical Method	Special Considerations (Ref. par. 10)
He/O_2 (10% O_2 or greater)	Each cylinder	Oxygen	Paramagnetic, Thermal Conductivity or Polarographic	
He/O_2 (Less than 10% O_2)	Each cylinder	Oxygen	Consult Specialty Gas Technical Manager	

9. ANALYSIS REQUIREMENTS - PURCHASED PRODUCT

Product	Sample	Analysis Required	Analytical Method	Special Considerations (Ref. par. 10)
Liquid & Gaseous Ar, O_2, N_2, He, H_2				10.9

10. GENERAL INFORMATION

10.1 The plant superintendent shall be responsible for establishing the frequency of analysis for the residual contents of tube trailers. When establishing this frequency, he should consider:

(a) the customer's purity requirement
(b) his knowledge of the production plant process
(c) his knowledge of plant operation parameters
(d) histories of customer contamination of our tube trailers
(e) his own responsibility for assuring that all product meets customer requirements

10.2 High-pressure gas samples for dew point measurement are taken from a sample line installed directly at the gauge coupling, thereby eliminating the need for a pressure regulator. The sample line should be as short as possible--never longer than 18 inches. If appropriate, a tripod is supplied to support the dew point apparatus close to the gauge coupling.

10.3 An analyzer which utilizes a paramagnetic principle can be, used as a substitute for the Orsat provided the full scale reading is no more than 2%, e.g. the 98 - 100% Beckman Paramagnetic Analyzer.

10.4 All liquids or gases purchased for pump filling or transfilling into medical cylinders must be accompanied by an analysis or be covered by a guaranty per requirements of Section 1.2.1.

10.5 When a bulk delivery is made to the cylinder fill bulk storage tank during the shift, a second cylinder representative of this product shall also be analyzed for total purity.

10.6 The Oxygen Trace Analyzer used for the analysis shall be capable of reading 0 - 10 ppm O_2 full scale. Examples are the Analytic Systems or Delphi Industries Electrochemical Oxygen Trace Analyzer.

10.7 The Ion-Mobility Analyzer used for argon analysis shall be capable of reading 0 - 50 ppm nitrogen in argon or less.

10.8 When tube trailers are filled by other than APCI facilities for delivery to APCI production facilities, analyses shall be performed on that trailer as it is received at the APCI facility in accordance with APCI requirements on filled trailers.

10.9 All gaseous products procured from other than APCI production facilities, whether purchased or product trade, shall meet all requirements of APCI produced products in regard to product purity and analysis.

10.10 The Dew Point method of performing moisture analysis shall also be utilized to detect oil. Oil will cause a "dew" on the mirror which will not disappear upon warming.

10.11 See Section 10 of DOM, Volume I for IGD product purity specifications.

2

COLD BOX LEAKS

I. PURPOSE

To establish a standard procedure that will enable Operations personnel to deal effectively with known or suspected cold box leaks.

II. RESPONSIBILITY

Plant Managers, Maintenance Superintendents, and operating personnel are responsible for compliance with the provisions of this procedure as applicable.

III. PROCEDURE

A. General

1. Procedures for dealing with cold box leaks are necessary in a good maintenance program. Despite continuous nitrogen purging of the cold box, a small liquid oxygen leak can raise the concentration of oxygen to limits that are unsafe for operation and maintenance.

2. Cold box atmospheres shall be monitored weekly for oxygen content to ensure that nitrogen purge is adequate and that no oxygen leakage exists. Monitoring shall be done at several points on each cold box, especailly around oxygen pumps, hydrocarbon adsorbers, and guard adsorbers. The appearance of frost spots or vapors may also prompt immediate checks.

   Note: From a safety standpoint, the main concern is with oxygen concentrations higher than 21 percent, and these will require action, but any radical deviation from plant norms shall be investigated. For example, if the jacket oxygen concentration of a plant has been running consistently at 15 percent and increases suddenly to 20 percent, a leak check may be worthwhile for process reasons, even though the safety level of 21 percent has not been exceeded.

   Nitrogen leaks shall not be neglected. Locating them may be important for the following reasons: (1) process considerations, (2) because of the possibility of an ashpyxiating atmosphere developing, and (3) because pressure ruptures could occur due to embrittlement of normally warm carbon steel piping or vessels. The procedures in

APCI DOCUMENT NO 99000227

COLD BOX LEAKS

B and C will deal chiefly with oxygen leakage, but portions will also apply to nitrogen.

Rev.

B. Action Criteria and Limitations

1. Indications of cold box atmospheres over 21 percent oxygen will require an immediate increase of nitrogen purge. Be sure to check all susceptible areas to insure the oxygen content is 21 percent or lower. Increasing the purge to reduce the oxygen concentration will be limited by:

   a. Availability of sufficient nitrogen to reduce the oxygen concentration to 21 percent or lower.

   b. Large frost spots resulting from the purge. These frost spots may be due to a leak large enough to prevent purge nitrogen heat from warming areas sufficiently or because it is channeling through the box and all nitrogen discharges on a limited area.

2. If increased purge cannot reduce the oxygen content to 21 percent or lower, or if you reach the above mentioned purge limitations and have large frost spots, immediate action shall be taken to locate and repair the leak. If, after finding the leak, it is necessary to shut the plant down for repairs, the Regional Manager shall be advised of the facts and he, in turn, shall contact the Operations Production Manager and Safety Director to determine further action.

C. Finding Leaks

The following hints are intended to be helpful as a guide to finding leaks. An attempt has been made to list a normal sequence for the average situation, but differing circumstances make it impossible to prescribe a definite course of action. Individual plant peculiarities, the magnitude of the leak, and the nature of surrounding equipment will dictate the sequence to follow.

1. It is logical to attempt to locate the leak while the plant is operating, if the proper consideration is given to the usual hazards associated with cryogenic liquids, i.e. liquid burns to personnel, increased flammability of materials caused by high oxygen concentrations, and asphyxiation caused by low oxygen concentrations.

COLD BOX LEAKS

2. If possible, increase the nitrogen purge to reduce the oxygen content to 21 percent (or as low as possible) until the leak is located. A clean length of pipe or hose temporarily tied into the reactivation blower can be used. Valve seal boots or removable panels can be used as inlets to the box during supplementary purge. Remember that to increase the purge flow is at best only a temporary measure, particularly for bad leaks. Supplementary purging may decrease the concentration at the point of leakage.

3. Use a Beckman D-2 or similar analyzer to locate the area of highest concentration. A probe, made of clean 1/4-inch stainless steel pipe of any proctical length, is a very effective tool when used with the analyzer. The probe should be tapered and sealed at one end and should have four 1/8-inch holes drilled in the side near the tapered end. If necessary, drill holes to admit the probe (use a drill stop so that the drill will penetrate only the jacket). To avoid defacing the jacket, valve boots and panel bolts can also be loosened. The drilled holes can be made the proper size so that they can be tapped for standard pipe or machine screws to plug them after they have been used. The highest purity obtained will be a clue to the location of the leak. If the highest purity obtainable is 30 to 35 percent oxygen, the leak will probably be in the crude oxygen circuit. If it is 75 percent or higher, the leak may be in the lower section of the low-pressure column or the condenser. The probe size will affect the concentration reading. It should be as close to the outside diameter of the analyzer sampling tube as practical. Atmospheric influx will also affect the reading, therefore, the distance between the actual and the jacket penetration and the size of the jacket opening are factors that will influence the reading and will need to be considered. Purge nitrogen outlets will also influence the reading. The purge valve may be turned off to take the probe tests, but should be opened again as soon after testing as possible.

4. Check with personnel who may be more familiar with particular plants and their possible weaknesses. For instance, 25 T/D plants had quite a few cases where the low-pressure column tray joints broke near the condenser or at column supports; "E" size standard plants have expansion bellows; and some of the original aluminum columns were subject to breakage at the pressure taps welded into the column shell.

COLD BOX LEAKS

5. Check prints for the areas most likely to cause problems. Flanges, expansion bellows, valve bonnets, orifice unions, etc. would be more likely to leak than welded, soldered, or even threaded joints.

6. After checking the results of the atmospheric analysis, reviewing prints, obtaining a work permit, etc., remove the panel or cut into the box at the suspected area. On welded jackets, a chipping chisel or sabre saw should be used, and a nitrogen purge should be applied at the immediate area. Prints should also have been reviewed to prevent damage to lines and vessels within the box that are close to the jacket. Discontinue cutting periodically and probe ahead through the cut portion to avoid damage to items which may not appear on prints. Cutting torches should not be used for this work. Besides being hazardous, they will not do the neat job necessary for eventual replacement of the panels.

7. When digging into the insulation, chemical goggles or a face shield, long sleeved shirt, clothing free of grease and oil, and asbestos gloves must be used. Personnel will then have maximum protection from a spray of liquid or cold gas.

8. During removal of the rock wool, liquid may be found and followed to its source. However, the liquid may often disappear with exposure to the atmosphere. In such cases, or if it is a gas leak, it may be possible to see or feel the direction from which most of the flow is coming and work in that direction. It should also be remembered that frost spots or liquid at the bottom of a jacket can often be caused by liquid dripping from leaks at higher elevations. Here again the analyzer can be used to check the concentration to trace the leak back to its source.

9. Where deep penetration of large boxes is necessary, investigation will be limited by the density of the vapors. The atmosphere must contain between 18 and 25 percent oxygen. Lifelines, fresh air blowers, self-contained breathing apparatus, and sufficient standby personnel outside the jacket shall be used as necessary. Storing of rock wool should be provided where required. Constant analysis of the atmosphere in all corners of the cavity is absolutely necessary. When vapors are excessive, it may be necessary to shut down the plant, dig into the box in the direction of the suspected leak, and inspect all joints for leakage. If no obvious leakage is discovered through inspection, the plant may need to be restarted and

checked under pressure as long as the man can remain inside. Repeat this digging, inspection, and startup as often as necessary.

10. As a last resort, it may be necessary to defrost the plant and pressure test the various circuits, checking for pressure drop. This is difficult because of possible leakage through valves and because heat transfer to cold insulation will influence pressure drop. If the leak can be isolated to a main circuit, it may be possible to pinpoint it by valving off smaller sections of that same circuit and noting changes in pressure drop rates. As a final check, valves may need to be removed and blank flanges plugs, etc., installed to insure and airtight system.

D. Repairing Leaks

1. If the leak or leaks are located and can be repaired without shutting down the plant, first provide a temporary increase in the purge in the area of the leak with a clean pipe or hose from the reactivation blower discharge or other available source. Insure that the general working area is clean, free of oil contamination or any flammable material. Either remove a convenient bolted panel or, if necessary, use a sabre saw to cut a panel opening near the leak. Never use a torch to cut a panel during operation. Remove enough rock wool to expose the leaking flange or valve bonnet. Repair the leak if possible, replace rock wool, being sure it is free of oil contamination (use fresh rock wool if possible), and bolt panel in place.

2. If the leak or leaks are located and cannot be repaired without shutting down the plant, contact your Regional office as to a further course of action.

IV. RELATED PROCEDURES

V. RELATED FORMS

Air Products and Chemicals INC

See Document Numbers: 990002040
990002050
990002060
990002070

APCI DOCUMENT NO. 990002238

INSTRUMENTATION PREVENTIVE MAINTENANCE

I. PURPOSE

To establish a general inspection and maintenance program for plant instrumentation, on which the programs of the individual plants can be based.

II. RESPONSIBILITY

The plant management and operating personnel of each plant are responsible for establishing a maintenance program for their plant based on this general program and for adhering to the maintenance schedule.

III. PROCEDURE

This procedure treats the maintenance of control valves, analyzers, process instruments, and pay meters. For safety valve maintenance, see section 6.02; for gages, see section 1.10.

A. Schedule

1. Daily Inspection

a. Calibrate all analyzers unless otherwise noted.

b. Check flow rates on analyzer rotameters.

c. Check standardization and reference cylinders. (Do not use cylinders that are pressurized to less than 50 psig.)

2. Weekly Maintenance

a. Check and zero rotameter pay meters.

b. Check chart drives for proper operation.

c. Clean pens.

d. Check liquid levels in the oxygen trace analyzers.

e. Check automatic valves for proper operation.

f. Check automatic valve packing for leaks.

APCI DOCUMENT NO 99000229

INSTRUMENTATION PREVENTIVE MAINTENANCE

3. Monthly Maintenance

a. Calibrate all instruments, including recorders, controllers, indicators, transmitters, and pay meters.

b. Clean instruments.

c. Lubricate the instruments if recommended by the vendor.

d. Repair or replace worn parts.

e. Check instrument air filters for moisture and dirt. Clean or replace elements as applicable.

f. Check alarms and shutdown settings and controls (every 6 months).

g. Lubricate valve hand-operators.

h. Stroke and calibrate the valves.

B. Maintenance Guidelines

1. Pneumatic Controls

a. Do not oil pneumatic control units since oil can become gummy, collect dirt, and foul nozzles, ports, and tubing.

b. Drain drip wells and moisture traps frequently enough to keep water out of the lines.

c. Clean restriction screws, needle valves, and nozzles with fine wires.

d. Leak-test the piping and connections with soap solutions.

NOTE

No leaks can be tolerated between the controller and the diaphragm motor valve.

INSTRUMENTATION PREVENTIVE MAINTENANCE

e. Inspect the control units for dirt and corrosion that might cause excessive friction in the linkage system. Clean the units with an approved solvent, such as Methylene Chloride. Use a soft pencil brush to remove dirt that remains on the unit.

NOTE

When cleaning the units with solvent, wear chemical goggles for safety.

2. Differential Pressure Indicators and Transmitters

Follow the pneumatic control guidelines, above.

3. Electronic Recorders

a. Inspect and clean the recorder and lubricate its bearings according to the manufacturer's specifications.

b. Lubricate the motor bearings with a good grade of instrument or clock oil. There are usually oil holes on the bearings to be lubricated. Do not oil in excess.

c. Inspect the drive cables for wear; replace worn parts.

d. Clean the electrical components and check them for tightness.

e. If electronic tubes are replaced, readjust the amplifier gain control.

f. Clean the slide wires with a contact solvent or a dry toothbrush.

4. Analyzers

a. Check solenoids or valves for leakage.

NOTE

Use a soap solution compatible with oxygen (for example, an Ivory soap solution).

INSTRUMENTATION PREVENTIVE MAINTENANCE

b. Check sampling system for proper operation and tightness.

c. Examine analyzer leads and terminals for tightness.

d. Check sample gas rotameters and clean if necessary.

e. Check calibration gas cylinders; replace cylinder if pressure is 50 psig or less.

f. Perform maintenance to meet manufacturer's specifications.

5. Control Valves and Positioners

a. Clean components until they are free of oil and dirt.

b. Check for leaks. The smallest leak can interfere with a positioner's operation.

c. Clean pilot valve.

d. Replace defective material immediately. Do not wait for faulty operation to make repairs mandatory.

e. Lubricate the force lever and spring lever pivot bearing.

f. Tighten the valve packing to prevent leaks.

g. Lubricate valve hand-operators.

6. Production (Pay) Meters

a. Calibrate the meters.

b. Check and calibrate the temperature and pressure compensation.

c. Check and calibrate the integrator.

d. Check the orifice plate approximately once a year to see that it is clean and the edge is sharp.

e. Clean the orifice run if there is dirt and foreign material behind the orifice plate.

INSTRUMENTATION PREVENTIVE MAINTENANCE

IV. RELATED PROCEDURES

1.10 Pressure Gage Safety Requirements

6.10 Preventive Maintenance Scheduling-Reporting

V. RELATED FORMS

SAFETY VALVES AND RUPTURE DISCS

I. PURPOSE

To establish a standard procedure that will (1) familiarize persons who are responsible for Operations maintenance with the ASME codes and APCI standards that pertain to safety valves and rupture discs; (2) set forth a schedule for changing or testing safety valves; (3) spell out methods for testing; (4) provide instructions for record keeping; and (5) impart general information that is useful in the maintenance of safety valves and rupture discs.

II. RESPONSIBILITY

The Plant Manager and Maintenance Superintendent are responsible for compliance with the provisions of this procedure.

III. PROCEDURE

A. ASME Codes

1. Safety valve settings may not exceed the maximum allowable working pressure (MAWP) of the vessel. If the capacity is supplied by more than one safety or relief valve, only one valve need be set to open at a pressure not exceeding the maximum allowable working pressure of the vessel; the other valves may be set to open at a higher pressure, but dare not exceed 105 percent of the MAWP.

2. Relieving capacity of safety valves on all unfired pressure vessels other than unfired steam boilers shall be sufficient to prevent a rise of pressure in the vessel of more than 10 percent above the allowable working pressure.

3. Where an additional hazard can be created by exposure of a pressure vessel to fire or unexpected sources of external heat (for example, vessels used to store liquefied flammable gases) supplemental pressure-relieving devices shall be installed to protect against excessive pressure. Such supplemental pressure-relieving devices shall be capable of preventing the pressure from rising more than 20 percent above the MAWP of the vessel.

4. The spring in a safety valve in service for pressures up to and including 250 psig shall not be reset for any pressure higher than 10 percent above or lower than 10 percent below that for which

APCI DOCUMENT NO. 9999230

SAFETY VALVES AND RUPTURE DISCS

the valve is marked. For safety valves in service at higher pressures than 250 psi, the springs shall not be reset for any pressure higher than 5 percent above or lower than 5 percent below that for which the safety valve is marked. If a change in set pressure is made, the data plate must be restamped or replaced.

5. If the operating conditions of a valve are changed so that the valve requires another spring, rated for a different pressure, the relief valve setting shall be adjusted by the valve manufacturer or by an individual certified by the manufacturer. The valve shall be marked by either of them in conformance with the Unfired Pressure Vessels Code, Section VIII, Par. UG-129.

6. Pressure-relieving devices shall be constructed, located, and installed so that they are readily accessible for inspection and repair, and so that they cannot be rendered inoperative. They shall be selected on the basis of their intended service.

7. Rupture discs may be used in place of safety valves on vessels containing substances that may render a safety valve inoperative, where a loss of valuable material by leakage should be avoided, or where contamination of the atmosphere by noxious gases must be avoided.

8. Each safety and relief valve for steam and air service shall have a substantial lifting device so that the disc can be lifted from its seat when the pressure on the vessel is 75 percent of that at which the valve is set to blow.

9. Every rupture disc shall have a specified bursting pressure at a specified temperature, shall be marked with a lot number, and shall be guaranteed by its manufacturer to burst within 5 percent (plus or minus) of its specified bursting pressure.

10. There shall be no intervening stop valves between the vessel and its protective device or devices, or between the protective device or devices and the point of discharge, except:

    a. When these stop valves are so constructed or positively controlled that closing all of them at once will not reduce the pressure-relieving capacity of the unaffected relieving devices below that required.

SAFETY VALVES AND RUPTURE DISCS

b. When a vessel in which pressure can be generated because of service conditions has a full-stop valve between it and its pressure-relieving device, it shall only be used for inspection and repair purposes. When such a stop valve is provided, it shall be arranged to be locked or sealed open, and it shall not be closed except by an authorized person, who shall stay there while the vessel is operating with the valve closed, and who shall relock or reseal the stop valve open before leaving the station. A gauge that indicates pressure in the vessel or circuit must be visible to the man in attendance while the valve is closed. The man in attendance must be familiar with emergency procedures if vessel pressure should arise.

11. If further details are desired, check the latest edition of the ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels, Section VIII.

B. APCI Design Standards

1. Valves for service temperatures of -20°F and lower are designated as COLD service. Iron and cold rolled steel parts will not be permitted in this service, except for carbon steel springs.

2. Recommended materials of construction for various services are tabulated below. These will vary with the manufacturer, but the table is useful as a guide for minimum cost.

Set Pressure	Temp., °F	Body Material	Trim Material	Spring Material	Spring Housing Material	Compression Screw Material
To 250#	-20 to +400	Bronze	Bronze	Car. Steel Cad. Plated	Bronze	Car. Steel
To 250#	-20 to -325	"	"	"	"	Stainless Steel
250# and up	-20 to +400	Carbon Steel	Carbon Steel	Car. Steel Cad. Plate	Car. Steel	Car. Steel
250# and up	-20 to -325	Stainless Steel	Stainless Steel	"	Stainless Steel	Stainless Steel

SAFETY VALVES AND RUPTURE DISCS

3. Valves to be used on vibrating installations shall have all parts that are subject to loosening wire sealed or pinned. All bolts, nuts, and caps shall be wire sealed. Screwed-in nozzles shall be pinned. Lift levers shall be spring-loaded to eliminate lever vibration. (Materials for converting to spring-loaded levers can be obtained from most vendors if nameplate data is supplied.)

C. Routine Inspection Requirements and Considerations

1. Safety valves and rupture discs shall be checked routinely for leakage and, if necessary, removed and repaired or replaced.

2. Seals shall be examined for breakage and evidence of tampering. Seals and/or wires which appear unlikely to last another year can be replaced if they are intact. If they are broke, missing, or rusted through to the point where it would be possible to change the valve setting, it will be necessary to remove and test the valve, and to repair or replace it. Lead seals, if used with brass or stainless steel wire will minimize this type of maintenance.

3. Valves must have a vendor tag or suitable replacement with the set pressure legible. If the tag has deteriorated to the point where it may be illegible within a year, an appropriate tag can be installed to eliminate the possible need for valve work the following year. If the tag is missing or illegible, the valve must be removed and tested or replaced.

4. Inspect the valve for general condition. Check inside the discharge port for loose or missing parts, broken springs, excessive corrosion, foreign material or obstructions. Repair, test, or replace the valve or parts as necessary. Valves with discharge ports piped to other areas or to a vent system shall have these pipes removed for inspection. Install unions or flanges next to the valve, if necessary, for convenience in making this annual check. When the unit is operating, inspections of discharge ports shall be made by using a light and mirror to prevent injury should the valve blow during the inspection. Keep to one side of the discharge port. To avoid falls or serious accidents which could occur due to normal reaction should a safety valve blow while the inspection is being made, high-pressure valves, or valves at high elevations that make it necessary to work from a ladder shall be inspected during down periods.

SAFETY VALVES AND RUPTURE DISCS

5. All valves located outdoors and not under a roof shall have some protection provided for their internal parts. Valves not headered shall have a pipe nipple in the discharge port with the lower portion of the end cut at a 45-degree angle to prevent rain, etc. from entering. A street elbow faced downward can be used where it would not present a hazard to personnel or equipment. Bonnet vents shall have similar protection. Plastic bags may be used to cover valves but should be relatively loose so that condensate will not accumulate inside the bag and on the valve.

6. Bonnet vents shall not be plugged, they shall be protected from inclement weather with nipples or street elbows as noted in 5, above. Bonnet vents on valves in flammable gas service shall be piped to vent stacks.

D. Test or Changeout Frequency

1. ALL SAFETY VALVES, REGARDLESS OF SERVICE, shall have an annual, visual, in-place inspection for those items outlined in C above, as applicable. Replace or test valves as necessary.

2. Air Compressor safety valves shall have one of the following checks biannually:

   a. Safety valves set at 125 psig and below can be operated with the lever after inspection to ensure that they are in sound condition.

   b. Safety valves set higher than 125 psig shall be removed and inspected through the inlet and discharge ports. Safety valves not meeting inspection requirements or safety valves of doubtful reliability must be replaced or tested and repaired.

3. Safety Valves which are icing up must be repaired or replaced immediately. If icing is due to heat leak, rather than to leakage, the insulation or piping shall be repaired or revised to suit the service.

4. Hydrogen Reformers. Steam and MEA service safety valves shall be removed and tested or replaced annually. All other safety valves shall be tested or replaced every 3 years.

SAFETY VALVES AND RUPTURE DISCS

5. Hydrogen Cylinder Filling Facilities. All safety valves shall be tested or replaced every 3 years.

6. Ammonia Plants. All safety valves shall be tested or replaced annually.

7. LNG Plants. Cold box safety valves shall be tested or replaced every 2 years. All other safety valves shall be done annually.

8. Acetylene Plants. All safety valves shall be replaced or tested every 2 years.

9. New ventures into processes not listed above will require yearly inspection and testing or replacement of safety valves until a history has been established to justify any change in frequencies. Plant management shall compile the history by keeping a log of malfunctions and test results as an aid to establishing the frequencies.

10. A visual inspection of all rupture discs shall be made annually to ensure that the vent is free of obstructions and that the disc has proper identification. See H.2, below.

E. Logging Safety Valve Operations and Changes

1. The scheduled period for testing or replacing safety valves shall begin when the valve is operated and is known to be within limits, when a new or reconditioned safety valve is installed, or when the safety valve is removed, tested, and replaced.

2. A log similar to Safety Valve Log, Exhibit A or a logbook shall be made for all safety valves. Logs for compressors, separator, and miscellaneous safety valves shall be made on separate sheets.

3. Logsheets shall be kept where operators and maintenance men can make their entries as necessary.

4. A duplicate master logsheet shall be kept within the facility office and shall be brought up to date once each month.

F. Facility Test Equipment

1. All facilities (except standard nitrogen plants) shall have a test

SAFETY VALVES AND RUPTURE DISCS

stand with a pressure capability limited by the available test fluid source. A flow diagram and suggested bench layout are shown on Exhibit B. Various options for the test fluid source are included on Exhibit C. Any other possible test fluids shall be cleared with the Operations Safety-Service Manager. It is intended that each plant have a minimum testing capability equal to that of its instrument air pressure. This is represented as Option 1 on Exhibit C, and the estimated price is $500.

2. Safety valve sizes to be tested will generally be limited to 2" NPT. Larger size safety valves shall be returned to the vendor or to outside repair facilities capable of performing this work (see Section G). A survey indicates that 90 percent of the safety valves at the average facility are 2-inch safety valves or smaller.

3. To assist in economic evaluation and practical pressure limitations the following statistics are outlined for the average facility:

   a. Forty percent of the safety valves are set to relieve at 100 psig or less.

   b. Sixty-six percent of the safety valves are set to relieve at 200 psig or less.

   c. Twenty-seven percent of the safety valves are set to relieve between 200 and 2000 psig.

   d. Seventy-two percent of the safety valves are thermal relief valves (usually ½" NPT), which will generally require very little test or repair work.

   e. Thirty-six percent of the safety valves on an air plant must be cleaned for oxygen service.

4. On Exhibit C, Options 1 and 2, the drier-filters shown shall be refrigeration type drier-filters, having a flanged cover for convenience in replacing the silica gel cartridge. They are manufactured by the Mueller Brass and Henry Valve companies. The moisture indicator is also a refrigeration type of indicator made by Sporlan. It is a color change indicator. Spares can be ordered through local refrigeration supply houses. Drier cases can be purchased in various sizes containing up to three cartridges. The upstream drier-filter and the moisture indicator shall be changed when the indicator

changes color. The downstream filter cartridge, used as a safety factor, should be installed in the upstream case after the indicator changes color. The new cartridge should be put in the downstream case. If a multiple cartridge unit is installed upstream and a single cartridge unit downstream, the downstream cartridge shall replace the cartridge on the inlet side of the upstream case. When installing new silica gel cartridges be sure to comply with the flow direction indicated on the cartridge, since the filter is built into the cartridge outlet side. Although a moisture indicator is used, the prime purpose here is to keep oil, not moisture, from getting into the test equipment. Moisture reaching the indicator informs the operator that the gel is saturated and that it would be possible to get oil downstream of the indicator.

5. Where test flows may require limitations (see Exhibit C, Options 1 and 5) to prevent excess "robbing" of process or product fluids, it may be advisable to install an orifice on the test bench side of the shutoff valve to prevent problems that could occur if the shutoff valve were inadvertently opened wide.

6. A cleaning tank and black light must be available for solvent cleaning and inspecting oxygen service valves. The area must be suitably ventilated and free of oil and grease.

7. The high-pressure filter shown on Exhibit B can be the standard filter, used downstream of APCI high-pressure pumping operations. The part number for the filter case is 52932C (code 3-337-99-0010) and for the filter element 24460A (code 4-337-05-0002). The number for spare copper gaskets for the filter case is 33792A (code 3-372-13-0015).

G. Safety Valve Testing

1. Safety valves returned to approved vendors (Lonergan and Anderson, Greenwood) need not be source inspected provided that they comply with the purchase order requirement to attach a metal tag on the sealing system, certifying that they have performed the retest and indicating the date of the retest and the test pressure.

2. If safety valves are tested and repaired at local outside repair facilities, an APCI man shall be called in for final checking and approval. The sealing system on the safety valve shall have a metal

tag that identifies the contractor and indicates the test date and test pressure. Before any repair work is assigned to an outside repair facility, the facility shall be inspected by a qualified person selected by area management, to ensure that the repair company has the equipment and knowledge to perform the work satisfactorily. Requests for assistance in making this evaluation shall be directed to the Safety-Service Manager.

3. APCI plant personnel assigned to safety valve testing and repair shall be qualified or trained to do this work. Plant or office management shall determine which personnel are qualified. If assistance is required, contact the Operations Safety-Service Manager. Information is available from safety valve manufacturers for training on specific types of valves. State and local codes and insurance carrier regulations shall be checked to determine if they contain specific requirements pertaining to safety valves.

4. Each safety relief valve shall be set, adjusted, and pop tested until three successive pop tests each fulfill the set pressure tolerances set forth in the latest edition of ASME Code, Section VIII, Unfired Pressure Vessels, plus or minus 2 psi for set pressures up to and including 70 psi, and plus or minus 3 percent for pressures above 70 psi.

5. A valve shall be tested, with its spindle vertical, on a manifold maintained for this purpose. It shall then be resealed, packaged, and put into stock or placed back in its original service.

6. Any leakage through the valve body is cause for rejection.

7. Each safety valve shall be tested for seat leakage following completion of the operational test (4, above), without removing the valve from the test stand. The test is as follows.

   a. All body and bonnet openings shall be blanked off.

   b. A tube having an inside diameter not larger than three-eighths of an inch and not exceeding 24 inches in length shall be used to detect seat leakage. One end of this tube shall be connected to the discharge side of the body (the drain port can be used), and the other end shall be immersed not more than one-half inch in clean water in a transparent container.

SAFETY VALVES AND RUPTURE DISCS

c. Air shall be applied to the valve inlet and maintained throughout the leakage test at either the test pressure listed in the Unit Specification or 85 percent of the set pressure, whichever is higher. Test pressures for all metal-to-metal seat, beveled-disc, wing-guided valves shall be 85 percent of set pressure. For wing-guided valves with seat seals of polymers, such as Teflon or Kel-F, the test pressure shall be 90 percent of the set pressure. Valves having set pressures of 30 psig or lower shall be tested for leakage at 3 psig less than the specified set pressure or at the test pressure specified in the Unit Specification, whichever value is higher.

d. The maximum allowable leakage shall be 20 bubbles in 2 minutes, beginning when the first bubble is sighted.

8. All valves and test fittings shall be degreased as a unit before they are installed on the test manifold. This is to maintain cleanliness for oxygen service valves. Test fittings shall be kept clean and stored accordingly.

9. The test source in-line filter (see Exhibit B) shall be inspected periodically with a black light. Test facilities which use dry oil-free nitrogen as the test fluid shall do this monthly. Those using air must do it before each batch of oxygen service safety valves are tested. The test manifold connection shall be checked with a black light before testing each batch of oxygen safety valves. If the filter is contaminated, a thorough check of the test fluid source must be made, and if there is contamination past the filter, the entire testing manifold must be solvent cleaned.

10. Oxygen service safety valves shall be tested in batches for better control of cleanliness and to reduce the number of black light checks. Extra care shall be taken, including covering the test bench with clean paper or plastic. Oxygen valves shall be packaged immediately after a batch has been tested or before a shift change.

11. Safety valves may be pop tested in place after proper attention has been paid to safety and process considerations.

H. Rupture Discs

1. The higher pressure of the range for which a disc is designed to

SAFETY VALVES AND RUPTURE DISCS

rupture may not exceed the maximum allowable working pressure of the vessel.

2. All rupture discs shall have a visible, legible manufacturer's metal tag attached, indicating the manufacturer, design or type number and lot number, size, maximum and minimum bursting pressure in psig, coincident disc temperature in °F, and capacity in CFM of air or applicable fluid.

I. General

1. Discharge from safety valves in oxygen, flammable gas, cold liquid, and inert gas service must be vented to a safe location to prevent fire and personnel hazards.

2. Discharge lines from all safety devices shall be designed to facilitate draining. The size of these lines shall not cause a reduction in relieving capacity.

3. It is important when checking valves, to make sure that the setting cannot change due to vibration or to improper wrenching at installation, and that the setting cannot be changed without breaking a seal. On many types of valves, screws must be installed to lock and seal the setting mechanism.

4. A large hexagon-shaped valve body does not mean that the valve was designed to be wrenched on that surface. A specially sized "safety grip" is always provided at the mounting base. Never hold a valve body in a vise.

5. Information about defects on valves in service shall be sent back to the Operations Department so that the most troublesome valves can eventually be eliminated.

6. Safety valves in air and steam service shall conform to the ASME recommendation and have lifting levers. Air service shall be defined as all services up to the air expansion valve, before the high-pressure column or up to the exchanger switch valves on low-pressure cycle plants. Lifting levers are not required elsewhere, but may be used if special conditions require them, or if their use offers some advantage.

7. Thermal reliefs need not have levers. They are usually associated

SAFETY VALVES AND RUPTURE DISCS

with piping, not with vessels, and are therefore not subject to the ASME code.

8. Generally, safety valves shall not be checked by lifting the levers. Weakened valves have been known to fly apart when actuated. Paragraph D.2, above, states an exception to this general rule.

9. When lockout valves are closed to isolate relief devices for their replacement, a man must be stationed at the lockout valve until the replacement is complete. Closing a lockout valve associated with a relief device shall be authorized only by the plant manager or his delegated representative.

10. Information pertaining to relief valves is contained in the Safety Standards manual.

    a. 607.1.2.3 - Oxygen Compressors - page 5

    b. 607.1.12 - Air Separation Plants - pages 11, 12, and 13

    c. 610.1.2 - Air Separation Plant Checklist - page 3, item (d); page 5, item (r); page 6, items (z) and (aa)

    d. 610.1.5 - Air Separation Plant Checklist - Page 11, Items 17a and 17b, Page 12, Items 17d, 17e, 17f, 17h

    e. 610.2.1 - Acetylene Plant Checklist - Page 6

11. Safety valves for use in piping circuits for thermal relief or for liquid, where piping and tubing pressures are rated higher than the overall circuit, can have considerably lower popping pressures.

12. When a replacement safety valve with a particular set pressure is not available, a temporary safety valve of the same size may be used, provided the set pressure of the valve is not above the maximum circuit safety valve setting. The valve should be set high enough above the normal working pressure of the circuit to keep it from blowing during operation.

    Example: Reciprocating pump inlet normally operates at a maximum of 12 psig and has a safety valve set at 100 psig. If a 100-psig valve is not available, a valve with a lower setting (but higher than 15 psig) can be used.

SAFETY VALVES AND RUPTURE DISCS

13. Any upgrading of relief valves or rupture discs must be cleared through the Engineering Department. If the upgrading will exceed the MAWP of the vessel, it will require Engineering justification acknowledged by our insurance carriers, and/or state approval (depending on plant location) before any change is made. If it is merely a change that does not exceed the MAWP, Engineering approval is still required, and the plant manager must advise his insurance inspector of the change, the reason for it, and the engineering basis.

14. New safety valves shall be ordered through the Spare Parts Department. Information for ordering shall include vendor, inlet and discharge size, service fluid, type of lever, and relief capacity.

15. State or local codes must be investigated by plant managers. Where they exist, they shall take precedence over the above mentioned general rules, but if the general rules are more stringent than the local codes and will still meet local acceptance, the general rules shall be observed. Copies of the local codes shall be sent to the Preventive Maintenance group for review and incorporation into the PM program.

16. Polyethylene bag protection is recommended for safety valves exposed to corrosive atmospheres and severe plant or atmospheric elements.

17. Safety valve bonnet vents shall not be plugged to prevent rain or dust from entering the bonnet <u>unless</u> the valve has an internal pressure equalizing arrangement to prevent a pressure buildup on the bonnet. If a pressure buildup occurs with this type of valve, the actual relieving pressure will be equal to this gas pressure plus the spring pressure. In general, most valves that have a female pipe threaded outlet on the bonnet are not internal equalizing and shall not be plugged. Street elbows or a short nipple and an elbow, facing downward, shall be used to protect the bonnet from the elements. Plastic plugs, provided with many of these valves, can be drilled from the bottom to provide the necessary relief.

18. No open bonnets are permitted on safety valves in flammable gas service.

19. Safety valves with bonnet vents in flammable gas service shall have the bonnet vents piped to the manifold vent system. The discharge

port of these valves is usually piped to the vent system, and a piece of pipe or tubing need only be run from that bonnet vent to the discharge pipe of the same valve. Exceptions may be made to this type of bonnet vent piping if the valves are outdoors and situated so that fires in the area would not be a hazard to personnel or equipment. These exceptions are to be approved by the Operations Safety-Service Manager, the Regional Safety Engineer, or a member of the corporate Safety Department.

IV. RELATED PROCEDURES

V. RELATED FORMS

Safety Valve Log (Exhibit A)

Flow Diagram and Suggested Bench Layout (Exhibit B)

SV Test Facility Fluid Source Options (Exhibit C)

6585 Source Inspection Tag (Exhibit D)

3609 Valve Repair Tag (Exhibit E)

SAFETY VALVE LOG

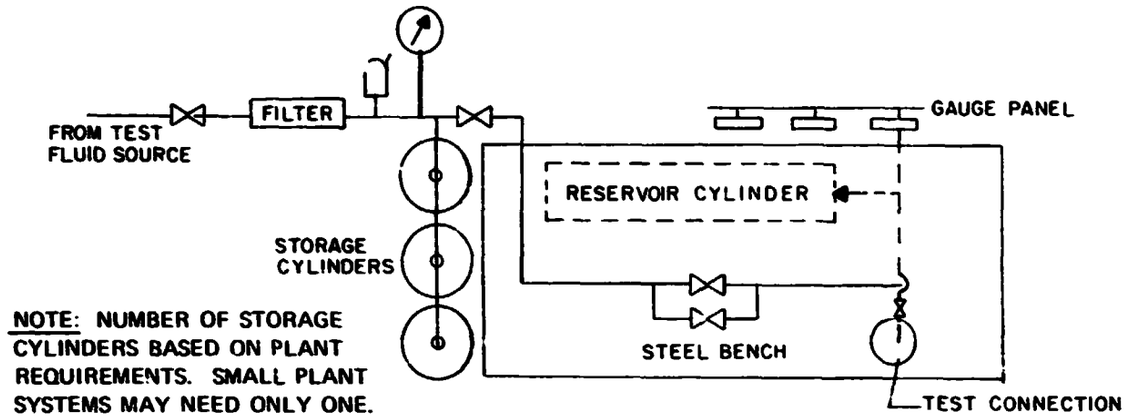
Year _____ Facility _____

Plant, Compressor _____

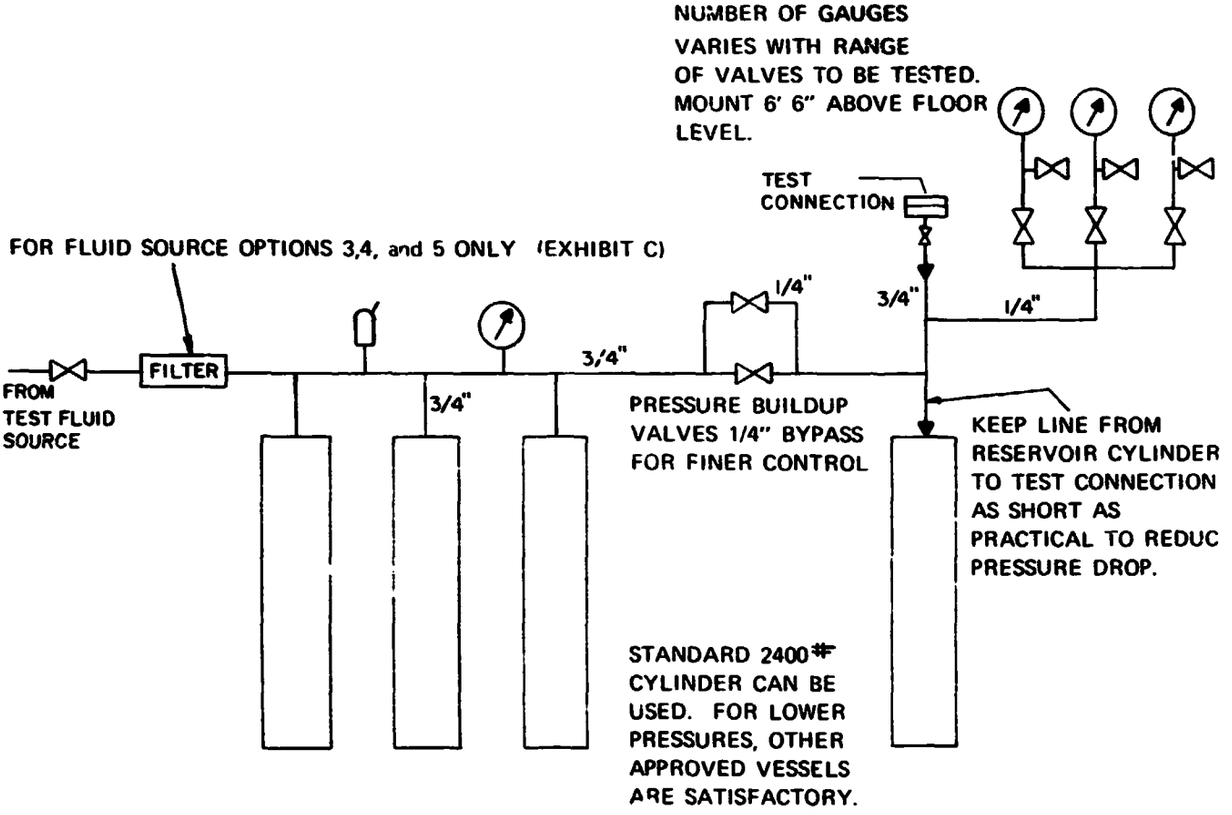
Indicate the month when the valve Operated (O), was repaired and checked (C), or a reconditioned one was installed (R), or a new valve was installed (N). If valve was operated, intentionally or not, indicate pressure in same space.

V.	Location	Design Setting	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.

FLOW DIAGRAM AND SUGGESTED BENCH LAYOUT

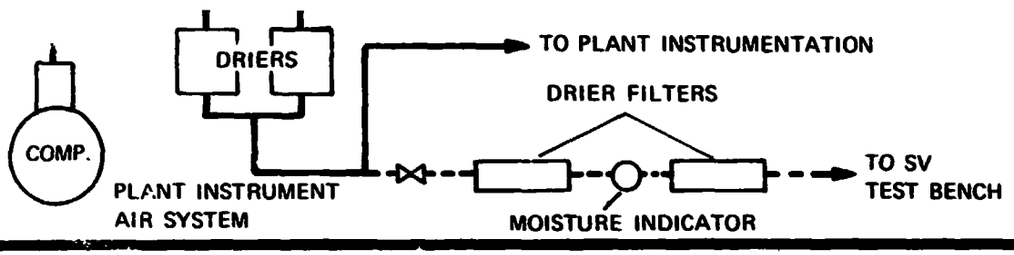


SUGGESTED BENCH LAYOUT
(Top View)

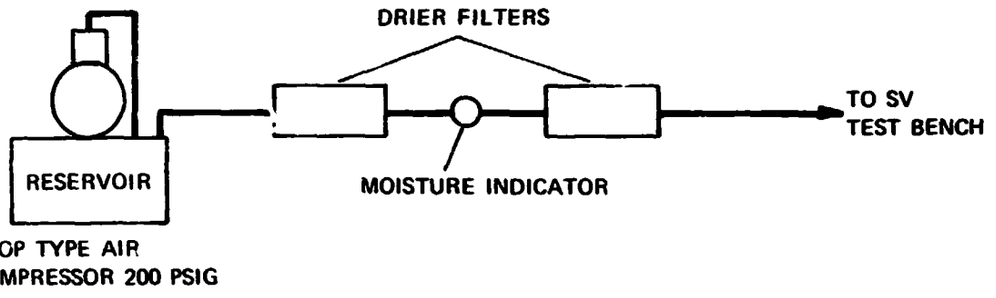


FLOW DIAGRAM AND LINE SIZING

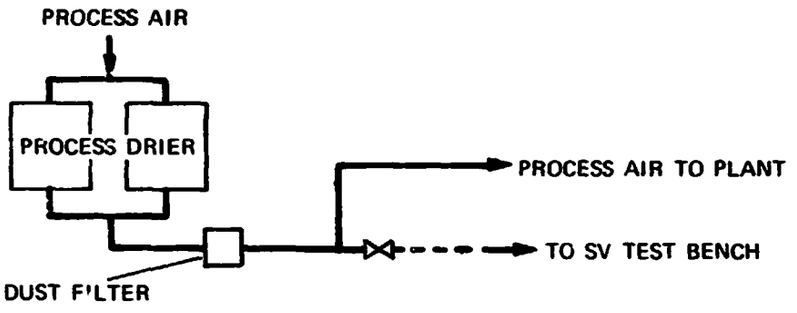
SV TEST FACILITY FLUID SOURCE OPTIONS



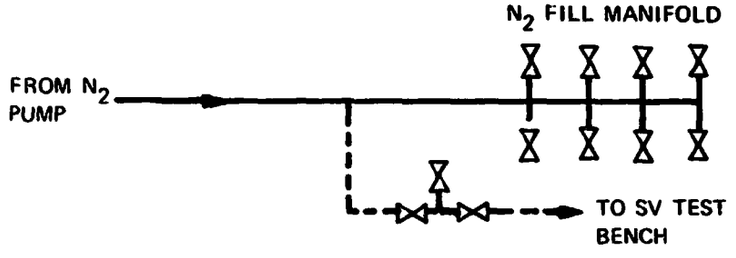
OPTION 1
100 PSIG LIMITATION



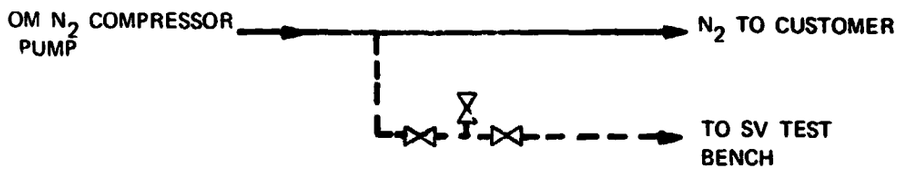
OPTION 2
200 PSIG LIMITATION



OPTION 3
LIMITATION – PLANT AIR
FEED HEAD PRESSURE



OPTION 4
LIMITATION – 2000 + PSIG



OPTION 5
LIMITATION – CUSTOMER
PRESSURE REQUIREMENTS

Air Products and Chemicals INC.

VENDOR_____

P. O. #_____ ITEM NO._____ QUANTITY_____

PART NO._____ REF._____

DESCRIPTION_____

INSPECTION WAIVER

Further inspection of this material at the vendor's plant is waived. This waiver does not constitute acceptance of the material, nor does it relieve the vendor of responsibility to furnish material in accordance with the purchase order.

(Signed)_____ SOURCE INSPECTOR _____ DATE

Form 6585 5/69

SOURCE INSPECTION TAG
(Green)

Form No. 6585
Material Code No. 4-847-51-0034

VALVE REPAIR TAG

RELIEF VALVE

Shipping Date_____

Facility_____

Part No._____

Valve No._____

Set. Press._____

LOX Service—Yes_____ No._____

Remarks:_____

Inspection—Repair Date:_____

By Whom_____

Setting_____

LOX Cleaned—Yes_____ No._____

Parts Replaced_____

Remarks:_____

FORM No. 3609

(Front)

VALVE REPAIR TAG

COMPRESSOR VALVE

Shipping Date_____

Facility_____

Compressor Mfg._____

Size_____

Service_____

Stage_____ Inlet_____ Disch._____

Mfg. No._____

APCI Code_____

Repair Date:_____

By Whom_____

Parts Replaced_____

Remarks:_____

(Back)

VALVE REPAIR TAG

Form No. 3609
Material Code No. 4-847-51-0033

APCI DOCUMENT
NO 99000231

EQUIPMENT	OVERDUE SINCE	DATE SCHEDULED	FREQUENCY (MONTHS)	CARD

MAINTENANCE TASK

TYPE	FAC PLANT	EQUIPMENT NO	TASK NO	CODE
				6
	4 6	7 9	11 13	16

DATE			EXPENDED TIME	
MONTH	DAY	YEAR	HOURS	MIN
19 20	21 22	23 24	25 28	29 30

MATERIAL USED/REMARKS 8

☐ 80 DELETE (EXPLAIN)

TASK PERFORMED BY _____ AUTHORIZED SIGNATURE _____

ACTION TAKEN

43 ADJUSTED	52 FILLED	61 REPAIRED
44 ALIGNED	53 INSPECTED	62 REPLACED
45 BLOWN OUT	54 LUBRICATED	63 TESTED
46 CALIBRATED	55 MEGGERED	64 TIGHTENED
47 CHANGED	56 OVERHAULED	65 WASHED OUT
48 CHECKED	57 PAINTED	66
49 CLEANED	58 RECORDED	67
50 DRAINED	59 REPACKED	68
51 EVACUATED	60 HISTORY RECORD CARD NOTED	

REASON DEFERRED

70 NO MECHANIC		75 RESCHEDULED
71 NO DOWNTIME		76 PRODUCTION DEMAND
72 NO SPARES		77 CUSTOMER DEMAND
73 NO TEST EQUIP		78 SHUTDOWN POSTPONED
74 OUT OF USE		79 WORK NOT JUSTIFIED

FORM 3610A Air Products and Chemicals, Inc.

OPERATIONS DEPARTMENT
PREVENTIVE MAINTENANCE REPORT
FEEDBACK CARD

APCI DOCUMENT
NO 99000231

Air Products and Chemicals INC

PLANT PREVENTIVE MAINTENANCE CONTROL

1. Purpose

To establish a centrally controlled system for all planned maintenance work, major or minor, regardless of whether the plant is running or shut down.

2. Scope

The Preventive Maintenance Control System schedules plant maintenance work, forecasts work to be done in future months, accumulates time expended and the number of times actions such as cleaning, filling, lubricating, overhauling or testing are performed, informs plant maintenance personnel of work not done and reports the level of compliance to Operations management. Maintenance tasks range in frequency from daily shifts to several years, depending on the equipment type, its loading and serviceability.

3. Definition

Preventive Maintenance is the planned, thorough inspection, lubrication, test or overhaul, made at predetermined scheduled intervals to ensure optimum onstream factors and operating profitability of all production plants.

4. Functional Outline

The Preventive Maintenance control system provides the Operations Department with a simple reporting system requiring a minimum of clerical work on the part of the individual plant maintenance personnel. The system also provides a daily, weekly and monthly reminder of work to be done and work overdue.

A. Scheduling

There are two separate control systems in operation. The IBM 360 computer controls tasks having a frequency of one month or more, and the IBM MTST Magnetic Tape Typewriter system controls daily and weekly tasks.

The 360 computer accurately schedules each task, based on the date the task was most recently performed, and the frequency associated with the task, while the MTST Magnetic Tape Typewriter schedules daily and weekly tasks.

These two data processing systems provide the Operations Department with overall administrative control of the schedules. Since the frequency of each task is fixed using the experience gained in all of APCI's plants over the last ten years. the schedules should be adhered to as closely as possible.

APCI DOCUMENT NO. 99000-232

4. Functional Outline - (Continued)

A. Scheduling - (Continued)

Five control documents reach the Plant Manager on or about the beginning of the month.

1. The Preventive Maintenance Schedule for the current month.
2. The Projected Preventive Maintenance Schedule for the two months following the current month.
3. The current month's feedback cards.
4. Daily preventive maintenance checklist cards for the current month.
5. Weekly preventive maintenance checklist cards for the current month.

The Projected Preventive Maintenance Schedule is a projection of all maintenance tasks for the two months following the current month, and it allows the planning of task performance in case an emergency shutdown occurs.

The feedback cards are returned at the end of every month to the Operations Department and serve as information carriers which report the performance and state of each task. Daily and weekly checklist cards are kept on file at the operating plant for future reference and are periodically audited at the plant by Operations management.

B. Evaluation

The reporting of preventive maintenance tasks which are performed on time, performed late, or remain in a deferred state allows an accurate evaluation of performance. The percent compliance to the schedule for each plant is separated into "normal" and "downtime" categories. This permits the separate evaluation of that portion of the schedule which is controllable by the plant manager with the plant running and that portion of the schedule which can only be accomplished when the plant is shut down.

C. Accumulation of Historical Information

Information which is reported via the feedback cards is accumulated and provides the "experience" from which preventive maintenance control is improved upon. The magnetic tape memories in the computer provide a complete range of master file summaries ranging from statistical analyses by plant, by equipment number, or by plant and equipment number.

D. Timing

In order to inform plant managers of overdue work, a monthly Addenda Schedule to the current month is printed at the same time as the performance report for the preceeding month. Plant managers may therefore expect to receive the following during any one month:

4. Functional Outline - (Continued)

D. Timing - (Continued)

At the beginning of the month:

1. The computer generated Preventive Maintenance Schedule, together with the associated set of feedback cards for the current month.

2. The Projected Preventive Maintenance Schedule for the two following months.

3. The Daily and Weekly checklist cards for the month.

In the middle of the month:

1. The performance report for the preceeding month.

2. The current month's Addenda Schedule showing work overdue, and an associated set of feedback cards.

5. PM System Details

A. PM Manual

The PM manual is prepared by maintenance engineers listing the specific maintenance tasks for each equipment item at the operating plants. The manufacturer's recommendations and APCI's own experience are considered in determining the extent of coverage for maintenance procedures and frequency.

Differentiation between running maintenance and shutdown maintenance is also made. As operating requirements change, these procedures are improved and updated and revised pages are issued to keep the manual current. A PM manual, Exhibit A-1, is issued for each plant for all tasks and contains the following information:

1. Under "EQUIPMENT NAME, SECTION & SUBSECTION NUMBER and TASK" is listed the type of equipment being serviced by the task and a sequence number. An example of this sequence number is given below with an explanation:

Number 01.20.31.10.0

a. The first four digits, 01.20 represents the equipment number on flowsheet, and in this instance is an Oxygen Compressor.

b. The fifth digit represents the plant number at the facility.

c. The sixth digit represents the craft responsible for the task.

1 - Mechanical
2 - Insturments
3 - Electrical

5. PM System Details - (Continued)

A. PM Manual - (Continued)

d. The seventh and eighth digits, listed under "TASK" are sequential numbers assigned to each preventive maintenance task.

e. The ninth digit provides means for adding tasks between existing tasks in the sequence.

2. Under "MAINTENANCE TASK DESCRIPTION", is listed the description of each preventive maintenance task.

3. Under "FREQUENCY" is listed the interval of time between successive scheduled preventive maintenance tasks.

4. Under "TYPE", is listed the indicator representing the type of task as follows:

0 - Normal Task
1 - Downtime Task
2 - Downtime Safety Valve Task
3 - Normal Safety Valve Task

B. PM Schedule

The computerized PM control system is in effect for all tasks with a frequency of one month up to several years. Daily and weekly tasks are scheduled by the IBM MTST Magnetic Tape Typewriter, Exhibit A-2.

The PM Schedule, Exhibit A-3, and the associated set of feedback cards are recieved by plant managers at the beginning of each month, and cover the PM tasks due to be performed in the current month. Also, included is an advance schedule of projected tasks for the two months following the current month, and the daily and weekly checklist cards with the scheduled tasks printed on them.

Copies of the PM Schedule are sent to the following:

1. Regional Manager
2. Plant Manager
3. Manager of Maintenance Engineering
4. Preventive Maintenance Coordinator

Feedback, Daily, and Weekly checklist cards are sent to plant managers only.

The PM Schedule, issued at the beginning of the month, contains a listing of all preventive maintenance work, of frequency one month or more, scheduled for the particular plant for the month indicated and contains the following specific information.

5. PM System Details - (Continued)

B. PM Schedule - (Continued)

1. The facility code, plant number, location and product. For example, FL-3 SPARROWS POINT, MD. - 900 T/D O_2-N_2-ARGON.

2. Under "EQUIPMENT NO./TASK" is the identification number which is identical to that listed under "EQUIPMENT NUMBER, SECTION & SUB-SECTION NUMBER and TASK" in the PM manual for each plant.

3. The information listed under "DESCRIPTION" contains a description of the equipment to be worked on, what the detailed preventive maintenance task is, and which craft is responsible for the maintenance.

4. Under "FREQ" is listed the frequency of the task in months.

5. Under "IND" is listed the notation "NRM" for a normal task, "DWT" for a task requiring a plant shutdown, "NSV" for a normal safety valve task, and "DSV" for a downtime safety valve task.

The Projected PM Schedule contains the information outlined above in paragraphs 1. through 5. and a column headed "MONTH". Under "MONTH" is listed the future scheduled date of each task.

C. Feedback Cards, Exhibit A-4

There are three different feedback cards, and although similar in appearance, each is colored differently -

Manila - Normal Feedback Card
Red - Downtime Feedback Card
Green - Safety Valve Feedback Card

The feedback cards are made up of sections, some preprinted and some blank. They arrive at the operating plant with the following sections preprinted with the following specific information:

SECTION NAME	INFORMATION
EQUIPMENT	- Contains a description of the equipment on which the task is to be performed.
OVERDUE SINCE	- If the task is overdue, the date on which the task was originally scheduled is recorded in this section.
DATE SCHEDULED	- Contains the month in which the task is scheduled to be performed.
FREQUENCY	- Contains the frequency of the task in months.
CARD	- Contains the card number serially numbered starting with 0001 for each set of feedback cards for a facility and plant. The letter "A" preceeds the number on "Addenda" feedback cards.

5. PM System Details - (Continued)

C. Feedback Cards, Exhibit A-4 - (Continued)

SECTION NAME	INFORMATION
MAINTENANCE TASK	- Contains the complete description of the preventive maintenance task as given in the PM manual.
TYPE	- Contains an indicator "NRM" representing a "normal" task (a task that can be performed while the plant is running), an indicator "DWT" representing a "downtime" task (a task that can only be performed during a plant shutdown), an indicator "NSV" or "DSV" representing a safety valve task (a task, either normal or downtime, that involves repairs to a safety valve.)
FAC-PLT	- Contains the facility location number and the plant number. For example - Plant No. 3 at Sparrows Point would be identified as FL-3.
EQUIPMENT NO. TASK NO.	- These sections list the sequence number, which is identical to the number found in the PM manual under "EQUIPMENT NAME, SECTION & SUBSECTION NUMBER and TASK".

The following sections are to be filled in on completion of each preventive maintenance task by plant maintenance personnel.

DATE	- The date when the task was completed (Month/Day/Year). The month must be marked in blocks 19 and 20, the day in 21 and 22, and the year in 23 and 24.
EXPENDED TIME	- The time taken in the execution of the task. Hours must be marked in blocks 25 to 28, and minutes in the blocks 29 and 30.
ACTION TAKEN	- Blocks 43 to 59 and 61 to 65 contain preprinted descriptions of actions taken as a result of the inspection. Maintenance personnel are to mark an "X" in the appropriate blocks.
HISTORY RECORD CARD NOTED	- If the History Record Card at the plant has been noted with details found during preventive maintenance, an "X" is to be placed in block 60.
REASON DEFERRED	- Blocks 70-79 contain printed descriptions of reasons why a task is deferred. If a task is deferred, maintenance personnel must insert an "X" in the appropriate block, indicating the reason deferred. If a downtime task is rescheduled, an "X" must be placed in block 75, and the rescheduled date must be put in the section marked "DATE".

5. PM System Details - (Continued)

C. Feedback Cards, Exhibit A-4 - (Continued)

SECTION NAME	INFORMATION
REMARKS	- Any pertinent comments concerning what was found when the preventive maintenance task was performed should be put in the remarks section. Use of this remarks section is encouraged as useful feedback information is accumulated for future reference.
TASK PERFORMED BY	- This section is provided for the signature of maintenance personnel performing the task.
AUTHORIZED SIGNATURE	- This section is provided for the signature of the plant manager or his designee.

By the last day of each month, all feedback cards, appropriately marked, must be returned, via first class mail, to APCI, Allentown, Pennsylvania, for the attention of R. Caligiuri for processing. If the preventive maintenance task was not done in the month scheduled, the feedback card must be marked with the reason deferred and returned.

Feedback cards describing a task performed must contain the follcwing information:

1. The date performed, blocks 19 to 24.
2. The expended time in hours and minutes, blocks 25 to 30.
3. Actions taken, blocks 43 to 65.

In order to facilitate keypunching and computer processing, all data written on the feedback card must be block printed, and only one character in each space. The "ACTION TAKEN" or "REASON DEFERRED" options must be designated with a large "X" marked in the block to the left of the desired description.

Feedback cards pertaining to normal tasks deferred must include the reasons deferred, blocks 70 to 74. The space provided under MATERIAL USED/REMARKS may be used to supplement reasons for deferment.

Analyse tasks with the idea of deleting the non-applicable tasks from the system and, changing the frequency to increase the time span between occurences based on operating experience. When several tasks are performed on a single machine and not scheduled in the same month, plant managers are requested to submit recommendations for the consolidation of such tasks.

Downtime tasks that cannot be performed during the initial month scheduled, due to a legitimate inability to obtain a plant shutdown, may be rescheduled for the next anticipated plant shutdown by in serting an "X" in block 75 RESCHEDULED under REASON DEFERRED, and entering the anticipated future shutdown date in blocks 19 and 20

5. PM System Details - (Continued)

C. Feedback Cards, Exhibit A-4 - (Continued)

for the month, and 22 and 23 for the year. The card will then be returned to the facility at the beginning of the rescheduled month. Feedback cards pertaining to downtime tasks deferred must include the reasons deferred, blocks 76 to 79.

When requesting the deletion of a task, insert an "X" in block 80 and explain the reason for the deletion in the MATERIAL USED/REMARKS section.

D. Projected Maintenance

A Schedule of Projected Preventive Maintenance is issued with the Preventive Maintenance Schedule at the beginning of the month for each plant at each facility for the two months following the current month. This advance schedule enables the plant manager to deploy his maintenance personnel more effectively and to take advantage of a plant shutdown to perform tasks not scheduled for the current month.

E. Preventive Maintenance Performance Report

The Preventive Maintenance Performance Report, Exhibit A-5, covers tasks which have a frequency of one month or more. The Daily and Weekly checklist cards are evaluated for performance compliance, cost effectiveness and profit contribution by the plant manager and periodic audits by persons from the Central Operations office and are not part of the computerized reporting system.

The Preventive Maintenance Performance Report is issued on or about the 15th of the month after the feedback cards for the previous month are received and processed. The report shows the tasks which are performed on time, performed late, are rescheduled or remain in a deferred state. For tasks completed, the action taken is given and for tasks deferred, the reason for deferral. All tasks with a frequency of more than one month which were previously deferred, will show the original date scheduled, whether or not they were completed during the month being evaluated.

The date completed and any additional remarks are listed under the column COMPLETED and the time, in hours, expended on the task is found under HOURS.

The Preventive Maintenance Performance Recap, Exhibit A-5, for each plant contains a total of the number of tasks scheduled, rescheduled and completed, the percentage compliance, and the time in hours for normal and downtime tasks. The number of tasks under "SCHEDULED" includes all tasks normally scheduled plus all tasks previously deferred and included in the Addenda Schedule for the month being reported. The number of tasks under "COMPLETED" includes only those tasks scheduled

5. PM System Details - (Continued)

E. Preventive Maintenance Performance Report - (Continued)

and completed in the month being reported. Minutes recorded on the feedback card are converted to hundredths of an hour on the report.

F. Preventive Maintenance Schedule - Addenda

All tasks of frequency of more than one month which are deferred will not appear on the Preventive Maintenance Schedule in succeeding months. However, they will appear on the Preventive Maintenance Schedule Addenda which is issued on or around the 15th of the month. The Addenda Schedule contains all tasks remaining in a deferred state, except for those downtime tasks rescheduled by use of block 75 in the feedback card. Addenda feedback cards are issued for each task on the Addenda Schedule, and must be sent back by the end of the month received. Addenda feedback cards have card numbers preceeded by the letter "A".

6. Summary

A chronological summary of each month's events follows:

A. At the beginning of the month:

1. Preventive Maintenance Schedule for the current month is issued for each plant at each facility.

2. An associated set of feedback cards for the current month.

3. Daily and weekly checklist cards for the current month.

4. The Projected Preventive Maintenance Schedule.

B. On or about the 15th of the month:

1. The Preventive Maintenance Report for the previous month.

2. The Addenda Schedule of all previously deferred tasks, if any.

3. An associated set of Addenda feedback cards.

C. By the last day of the month:

1. The feedback cards issued at the beginning and the middle of the month are returned to the Central Operations office for processing.

2. The Daily and weekly checklist cards are made part of the plant records.

RHC
June 1971

(Retyped 9 /25/72 sba)

Air Products and Chemicals
OPERATIONS DEPARTMENT

FORM 3516
REV 4/69

DATE 6/6/69

PREVENTIVE MAINTENANCE MANUAL

PAGE 14 OF 152

FACILITY CODE FL PLANT NO. 3 EQUIPMENT SECTION NO. 01.20.31

PLACE Sparrows Point TYPE Oxygen-Nitrogen-Argon EQUIPMENT Oxygen Compressor - Mechanical

EQUIPMENT NAME, SECTION & SUBSECTION NUMBER	TASK	MAINTENANCE TASK DESCRIPTION	FREQUENCY: DAILY	FREQUENCY: WEEKLY	FREQUENCY: MONTHLY	FREQUENCY: AS INDICATED	TYPE	MAN HRS. REQ.
01.20.31 Oxygen Compresaor (Mechanical)	09.0	Check cooling water system for leaks and repair all possible leaks.		X			0	
	10.0	Inspect foundation and grout for cracks. Repair and seal paint defects in grout. Inspect equipment for corrosion protection and touch-up paint requirements. Test run auxiliary oil pump.			X		0	
	12.0	Check foundation bolts for tightness. Take lubricating oil sample. Change oil only if analysis warrants. Clean reservoir at oil change.				6 Months	0	
	15.0	Hot check coupling alignment between motor and speed increaser. Inspect coupling for wear and relubricate. Check coupling alignment between speed increaser and 1st compressor case and between 1st and 2nd compressor cases. (See vendor's manual for tolerances). Inspect gears in speed increaser for wear and tooth contact.				12 Months	1	
	17.0	Inspect and take journal bearing clearances and record (.004" to .0065"). Check and record thrust bearings clearance (.015" to .022"). Inspect shaft seals for wear and for oil and desiccant contamination. Pay particular attention to all components for wear.				3 Months	1	
	20.0	Inspect waterside of oil cooler for fouling.				12 Months	1	
	21.0	Complete compressor disassembly, inspection and overhaul. Inspect condition of thrust and radial bearings, labyrinths, seals, and diaphragms. Magnaflux rotors and check balance. See vendors manual for dismantling and reassembly procedures. Inspect speed increaser bearings for wear and record clearances.				12 Months	1	

TYPE 0 - NORMAL TASK
1 - DOWNTIME TASK
2 - DOWNTIME SAFETY VALVE } REQUIRES PLANT SHUTDOWN
3 - NORMAL SAFETY VALVE

EXHIBIT A-1

DAILY AND WEEKLY CHECKLIST CARDS

MONTH	YEAR	FAC PLANT	EQUIPMENT NO	EQUIPMENT	SKILL	TEAM	CARD
March	70	FL-3	01.10.11	Main Air Compressor	Mechanical	A	001

TASK NO 01.0 — DAILY MAINTENANCE

Check compressor and motor for unusual noise or vibration.

REMARKS

TASK NO 02.0 — DAILY MAINTENANCE

Check lube oil pressure normal 45 psi.

REMARKS

DATE

MONTH	YEAR	FAC PLANT	EQUIPMENT NO	EQUIPMENT	SKILL	TEAM
March	70	FL-3	01.10.11	Main Air Compressor	Mechanical	A

TASK NO 03.0 — DAILY MAINTENANCE

Check bearing temperature on motor and compressor.

REMARKS

TASK NO 05.0 — DAILY MAINTENANCE

Check DP across oil filter. Vent spare filter and switch filters if DP exceeds 10 psi.

REMARKS

DATE

OPERATIONS DEPARTMENT — PREVENTIVE MAINTENANCE DAILY CHECKLIST

MONTH	YEAR	FAC PLANT	EQUIPMENT NO	EQUIPMENT	SKILL	TEAM	CARD
March	70	FL-3	01.10.31	Main Air Compressor	Mechanical	B	001

TASK NO 04.0 — WEEKLY MAINTENANCE

Test run auxiliary lube oil pump. Check motor bearing temperature by feel. Check for unusual noise or vibration.

WEEK 1 2 3 4 5 — INITIALS & REMARKS

TASK NO 05.0 — WEEKLY MAINTENANCE

Check motor bearing oil rings for rotation.

WEEK 1 2 3 4 5 — INITIALS & REMARKS

MONTH	YEAR	FAC PLANT	EQUIPMENT NO	EQUIPMENT	SKILL	TEAM
March	70	FL-3	01.20.31	Oxygen Compressor	Mechanical	B

TASK NO 08.0 — WEEKLY MAINTENANCE

Check condensate traps on intercoolers, aftercoolers and aftercooler separator for proper operation. Check condensate for discoloration.

WEEK 1 2 3 4 5 — INITIALS & REMARKS

TASK NO 09.0 — WEEKLY MAINTENANCE

Check cooling water system for leaks and repair all possible leaks.

WEEK 1 2 3 4 5 — INITIALS & REMARKS

OPERATIONS DEPARTMENT — PREVENTIVE MAINTENANCE WEEKLY CHECKLIST

EXHIBIT A-2

REPRODUCIBILITY OF THE ORIGINAL COPY IS POOR.

PREVENTIVE MAINTENANCE SCHEDULE

FL-3 SPARROWS POINT, MD. 900 T/D O2-N2-ARGON — PREVENTIVE MAINTENANCE SCHEDULE MAR 1970 — PAGE 197

EQUIP NO	TASK	DESCRIPTION	FREQ	IND
01.10.31		MAIN AIR COMPRESSOR - MECHANICAL	01	NRM
	11.0	RECORD VIBRATION READINGS ON ALL COMPRESSOR AND MOTOR BEARINGS.		
01.10.32		MAIN AIR [illegible] INSTRUMENTS	01	NRM
	20.0	INSPECT VIBRATION MONITORING EQUIPMENT TO ENSURE PROPER OPERATION OF VIBRATION DETECTION EQUIPMENT. ENTER IN REMARKS, ANY INOPERABLE CONDITION.		
01.20.31		OXYGEN COMPRESSOR - MECHANICAL	01	NRM
	10.0	INSPECT FOUNDATION AND GROUT FOR CRACKS. REPAIR AND SEAL PAINT DEFECTS IN GROUT. INSPECT EQUIPMENT FOR CORROSION PROTECTION AND TOUCH-UP PAINT REQUIREMENTS. TEST RUN AUXILIARY OIL PUMP.		
01.20.31		OXYGEN COMPRESSOR - MECHANICAL	12	OHT
	15.0	HOT CHECK COUPLING ALIGNMENT BETWEEN MOTOR AND SPEED INCREASER. INSPECT COUPLING FOR WEAR AND RELUBRICATE. CHECK COUPLING ALIGNMENT BETWEEN SPEED INCREASER AND 1ST COMPRESSOR CASE AND BETWEEN 1ST AND 2ND COMPRESSOR CASES. (SEE VENDORS MANUAL FOR TOLERANCES). INSPECT GEARS IN SPEED INCREASER FOR WEAR AND TOOTH CONTACT.		
01.20.31		OXYGEN COMPRESSOR - MECHANICAL	03	OHT
	17.0	INSPECT AND TAKE JOURNAL BEARING CLEARANCES AND RECORD (.006 IN TO .0065 IN). CHECK AND RECORD THRUST BEARING CLEARANCE (.015 IN TO .022). INSPECT SHAFT SEALS FOR WEAR AND FOR OIL AND DESICCANT CONTAMINATION. PAY PARTICULAR ATTENTION TO ALL COMPONENTS FOR WEAR.		

EXHIBIT A-3

FEEDBACK CARDS

EQUIPMENT: MAIN AIR COMPRESSOR - INSTRUMENTS
OVERDUE SINCE: —
DATE SCHEDULED: MAR 1970
FREQUENCY: 1
CARD: 0004

MAINTENANCE TASK:
INSPECT VIBRATION MONITORING EQUIPMENT TO ENSURE PROPER OPERATION OF VIBRATION DETECTION EQUIPMENT. ENTER IN REMARKS, ANY INOPERABLE CONDITION.

TYPE	FACILITY	EQUIPMENT NO.	TASK NO.	CRAFT
PRM	FL-3	01.20.32	22.0	6

DATE: 12 14 69
EXPENDED TIME: 1.0

MATERIAL USED/REMARKS: 8

☐ 80 DELETE (EXPLAIN)

TASK PERFORMED BY: [illegible]

ACTION TAKEN / REASON DEFERRED

OPERATIONS DEPARTMENT
PREVENTIVE MAINTENANCE REPORT
FEEDBACK CARD

FORM 3456 Parts and Chemicals

EQUIPMENT: OXYGEN COMPRESSOR - MECHANICAL
OVERDUE SINCE: —
DATE SCHEDULED: MAR 1970
FREQUENCY: 01
CARD: 0005

MAINTENANCE TASK:
INSPECT FOUNDATION AND GROUT FOR CRACKS. REPAIR AND SEAL PAINT DEFECTS IN GROUT. INSPECT EQUIPMENT FOR CORROSION PROTECTION AND TOUCH-UP PAINT REQUIREMENTS. TEST RUN AUXILIARY OIL PUMP.

TYPE	FACILITY	EQUIPMENT NO.	TASK NO.	CRAFT
NRM	FL-3	01.20.31	10.0	6

DATE: 12 23 70
EXPENDED TIME: 2.5

MATERIAL USED/REMARKS: 8

☐ 80 DELETE (EXPLAIN)

TASK PERFORMED BY: R Hoffman

ACTION TAKEN / REASON DEFERRED

OPERATIONS DEPARTMENT
PREVENTIVE MAINTENANCE REPORT
FEEDBACK CARD

FORM 3456 Parts and Chemicals

EQUIPMENT: OXYGEN COMPRESSOR - MECHANICAL
OVERDUE SINCE: JAN 1970
DATE SCHEDULED: MAR 1970
FREQUENCY: 12
CARD: 0005

MAINTENANCE TASK:
HOT CHECK COUPLING ALIGNMENT BETWEEN MOTOR AND SPEED INCREASER. INSPECT COUPLING FOR WEAR AND RELUBRICATE. CHECK COUPLING ALIGNMENT BETWEEN SPEED INCREASER AND 1ST COMPRESSOR CASE AND BETWEEN 1ST AND 2ND COMPRESSOR CASE. (SEE VENDORS MANUAL FOR TOLERANCES). INSPECT GEARS IN SPEED INCREASER FOR WEAR AND TOOTH CONTACT.

TYPE	FACILITY	EQUIPMENT NO.	TASK NO.	CRAFT
OHT	FL-3	01.20.21	15.0	6

DATE: 12 14 69
EXPENDED TIME: 4000

MATERIAL USED/REMARKS: 8
ITEMS 1, 9, 12 DEFERRED

☐ 80 DELETE (EXPLAIN)

TASK PERFORMED BY: Maint Dept

ACTION TAKEN / REASON DEFERRED

OPERATIONS DEPARTMENT
PREVENTIVE MAINTENANCE REPORT
FEEDBACK CARD

FORM 3456 Parts and Chemicals

EQUIPMENT: OXYGEN COMPRESSOR - MECHANICAL
OVERDUE SINCE: —
DATE SCHEDULED: MAR 1970
FREQUENCY: 03
CARD: 0006

MAINTENANCE TASK:
INSPECT AND TAKE JOURNAL BEARING CLEARANCES AND RECORD (.004 IN TO .0065 IN). CHECK AND RECORD THRUST BEARING CLEARANCE (.015 IN TO .022). INSPECT SHAFT SEALS FOR WEAR AND FOR OIL AND DESICCANT CONTAMINATION. PAY PARTICULAR ATTENTION TO ALL COMPONENTS FOR WEAR.

TYPE	FACILITY	EQUIPMENT NO.	TASK NO.	CRAFT
OHT	FL-3	01.20.31	17.0	6

DATE: 12 14 69
EXPENDED TIME: 15000

MATERIAL USED/REMARKS: 8

☐ 80 DELETE (EXPLAIN)

TASK PERFORMED BY: C T [illegible]

ACTION TAKEN / REASON DEFERRED

OPERATIONS DEPARTMENT
PREVENTIVE MAINTENANCE REPORT
FEEDBACK CARD

FORM 3456 Parts and Chemicals

EXHIBIT A-4

PM PERFORMANCE REPORT AND RECAP

FL-1 SPARROWS POINT, MD. PREVENTIVE MAINTENANCE PERFORMANCE REPORT MAR 1970 PAGE 319
900 T/D 02-N2-ARGON

EQ NO/TASK	DESCRIPTION	FREQ	SCHEDULED	IND	COMPLETED	HOURS
01.10.32	MAIN AIR COMPRESSOR - INSTRUMENTS					
20.0	INSPECT VIBRATION MONITORING EQUIPMENT TO ENSURE PROPER OPERATION OF VIBRATION DETECTION EQUIPMENT. ENTER IN REMARKS, ANY INOPERABLE CONDITION.	01	MAR 1970 ACTION TAKEN- CHECKED INSPECTED TESTED	NRM	03/23/70	.50
			TOTAL HOURS 01.10			2.25
01.20.31	OXYGEN COMPRESSOR - MECHANICAL					
10.0	INSPECT FOUNDATION AND GROUT FOR CRACKS. REPAIR AND SEAL PAINT DEFECTS IN GROUT. INSPECT EQUIPMENT FOR CORROSION PROTECTION AND TOUCH-UP PAINT REQUIREMENTS. TEST RUN AUXILIARY OIL PUMP.	01	MAR 1970 ACTION TAKEN- CHECKED INSPECTED TESTED	NRM	03/23/70	.42
01.20.31	OXYGEN COMPRESSOR - MECHANICAL					
15.0	HOT CHECK COUPLING ALIGNMENT BETWEEN MOTOR AND SPEED INCREASER. INSPECT COUPLING FOR WEAR AND RELUBRICATE. CHECK COUPLING ALIGNMENT BETWEEN SPEED INCREASER AND 1ST COMPRESSOR CASE AND BETWEEN 1ST AND 2ND COMPRESSOR CASES. (SEE VENDORS MANUAL FOR TOLERANCES). INSPECT GEARS IN SPEED INCREASER FOR WEAR AND TOOTH CONTACT.	12	MAR 1970 ACTION TAKEN- CHECKED CLEANED INSPECTED RECORDED	DWT	12/14/69 REMARKS- ITEMS 1 & 2 DEFERRED	48.00
01.20.31	OXYGEN COMPRESSOR - MECHANICAL					
17.0	INSPECT AND TAKE JOURNAL BEARING CLEARANCES AND RECORD (.004 IN TO .0065 IN). CHECK AND RECORD THRUST BEARING CLEARANCE (.015 IN TO .022). INSPECT SHAFT SEALS FOR WEAR AND FOR OIL AND DESICCANT CONTAMINATION. PAY PARTICULAR ATTENTION TO ALL COMPONENTS FOR WEAR.	03	MAR 1970 ACTION TAKEN- CHECKED CLEANED INSPECTED OVERHAULED RECORDED	DWT	12/14/69	150.00

FL-3 SPARROWS POINT, MD. PREVENTIVE MAINTENANCE PERFORMANCE RECAP MAR 1970 PAGE 358
900 T/D 02-N2-ARGON

	SCHEDULED	RESCHEDULED	TO BE COMPL	COMPLETED	PCT COMPLIANCE	TIME(HRS)
NORMAL TASKS	37		37	37	100.0%	28.84
DOWNTIME TASKS	41	29	12	12	100.0%	323.33
DOWNTIME SAFETY VALVE	118		118		.0%	.00
NORMAL SAFETY VALVE	3		3		.0%	.00
TOTAL	199	29	170	49		352.17

EXHIBIT A-5

SAFETY REPORTS AND FORMS

I. PURPOSE

To establish a standard procedure for using and submitting of the reports and forms necessary for Operations and Safety Department supervisors to perform their safety functions properly.

II. RESPONSIBILITY

Regional and Plant Managers are responsible for compliance with the provisions of this procedure as applicable. Responsibility for completing and distributing individual forms is indicated in the form descriptions that follow.

III. PROCEDURE

A. First Aid Report (Form 2019, Exhibit A).

1. Description. This form is filled out by the Assistant Plant Manager (shift supervisor or foreman) and submitted to the Plant Manager for all incidents requiring first aid. The Plant Manager uses these forms when he prepares the Monthly Summary of Injuries (Form 2021, Exhibit E) for the Safety Department.

2. Distribution. These forms are kept in the facility file; a log book may be kept instead of the forms. Contrary to the direction given in Safety Standard 625.0.1, it is NOT necessary to send a copy to the Safety Department.

B. First Report of Accident (Form LC-2850, Exhibit B, is a sample form and is for use in Pennsylvania only. Refer to Insurance Manual for Hartford Accident and Indemnity Company listing of District Offices, and for listing of State Agencies where applicable forms may be obtained).

1. Description. The First Report of Accident is to be used for any injury requiring medical attention more extensive than first aid. It is to be filled out by the Assistant Plant Manager (shift supervisor or foreman) and submitted to the Plant Manager.

NOTE

The Hartford Accident and Indemnity Company must also be notified by telephone immediately after the accident.

APCI DOCUMENT NO. 99000233

SAFETY REPORTS AND FORMS

2. Distribution:

a. Facility file

b. Safety Department

c. Personnel Department

d. Treasurer's Department (Insurance Section)

e. Vice President of Operations

f. Hartford Accident and Indemnity Company local office.

g. State Workmen's Compensation Agency, if required.

C. Supervisor Accident Investigation Report (Form 2020, Exhibit C).

1. Description. This report is used for every accident or injury involving lost time or unusual circumstances. It is filled out by the Plant Assistant Manager (Shift supervisor or foreman) and submitted to the Plant Manager.

2. Distribution:

a. Facility file

b. Safety Department

c. Vice President of Operations

d. Operations Safety-Service Manager.

D. Near Accidents, Unsafe Practices or Conditions (Form 2023, Exhibit D).

1. Description. This form is filled out after every potentially serious incident and whenever an unsafe practice or condition is discovered. This form is instrumental in preventing accidents at all plants where there may be similar processes, equipment etc. It is filled out by the Assistant Plant Manager (shift supervisor or foreman) and submitted to the Plant Manager.

2. Distribution:

a. Facility file

SAFETY REPORTS AND FORMS

b. Safety Department

c. Operations Safety-Service Manager

E. Monthly Summary of Injuries (Form 2021, Exhibit E).

1. Description. Each Plant Manager sends a summary of injuires at his plant each month to the Safety Department, which compiles the results and distributes them to Operations Management for review. If the results indicate that injuries have become considerably more frequent or more severe, management will initiate new preventive measures.

2. Distribution:

a. Facility file

b. W. L. Ball - Safety Department (by the 10th of the following month).

F. Monthly Plant Safety Survey (Form 2032, Exhibit F).

1. Description. This form is a general guide to be used by the Plant Manager during his monthly safety inspection. The Plant Manager can make the form more extensive or more specific for the special needs of his own plant.

2. Distribution. Facility file only, unless Operations Management advises otherwise.

G. Minutes of the Safety Meeting (Form 2030, Exhibit G).

1. Description. Minutes are prepared by the Plant Manager on this form after every safety meeting; meetings are held at every plant at least once a month.

2. Distribution:

a. Facility file

b. Operations Safety Engineers - Southern area facilities managed out of New Orleans shall forward them to A. L. Hatley in New Orleans. All others shall send them to E. Sheasby in Creighton (by the 10th of the following month).

SAFETY REPORTS AND FORMS

H. Monthly Report of Contamination Testing (Form 2033, Exhibit H).

1. Description. This form is completed at each air plant facility at the end of each month. The Operations Safety-Service manager, H. Master, will maintain historical records and compare them with past reports. Plant management and operators should always be watching for abnormal conditions and shall investigate the causes of such conditions. Results of these investigations shall be noted on the back of the form. If investigations are not reported on the form, the Operations Safety-Service Manager will investigate after his review. Other points pertaining to this report are as follows:

   a. Indications of acetylene, besides being stated in the report, also require immediate investigation and action. Notification by telephone shall be made to the Regional and Operations offices as soon as it is practical.

   b. When high box atmosphere (over 21 percent oxygen) is recorded on the form, the action taken or intended shall be described on the back of the form.

   c. Total hydrocarbons "Required" (points 1 and 2) must be reported each month. Depending on the process, some plants will only have one of these points. Normally, one of the "Required" points will be constantly monitored. When both points are on one plant, the constant monitor shall be on the reboiler sump or its equivalent.

   d. "Required" or "Optional" points that are not on constant monitor shall be checked and logged once per shift when requested. The average shall be calculated at the end of the month. The average maximum, and minimum figures shall be included in the report.

SAFETY REPORTS AND FORMS

e. Check of "Optional" points usually will not be required continuously. However, these checks must be made if such data would be helpful in solving a problem or if the information is requested by the Regional, Operations, or Safety office. All new plants shall check and report on all optional points for which taps have been provided for one year after plant startup so that an operating history of the plant and of that particular process can be compiled. Assuming that results are satisfactory, this practice shall be discontinued after one year. Air-to-column points shall be checked once each shift, then logged and reported opposite "Optional" point 5 on the form, as described in step d. Tests upstream and downstream of hydrocarbon or guard adsorbers shall be made just prior to switching cylinders. For purposes of comparison, the downstream test shall be taken as soon as practical after the upstream test.

f. Further details on this report and the contaminant test are given in Safety Standard 610.1.5, pages 12 and 13, and in the pocket-sized Operations Safety Manual, pages 38-40.

2. Distribution.

a. H. H. Master (by the 10th of the following month)

IV. RELATED PROCEDURES

1.06, Air Plant Reboiler Safety

1.06.01, Air Separation Plant Reboiler Safety - Nitrogen Plants.

5.16, Industrial Safety Policy, Plant Operations Manual.

5.21, Accident Reporting, Plant Operations Manual.

610.1.5, Safety Standard

625.0.1, Safety Standard

Operations Safety Manual, pp. 38-40.

Insurance Manual

SAFETY REPORTS AND FORMS

V. RELATED FORMS

2017, First Aid Report (Exhibit A)

2020, Supervisor Accident Ivestigation Report (Exhibit C)

2021, Monthly Summary of Injuries (Exhibit E)

2023, Near Accidents, Unsafe Practices or Conditions (Exhibit D)

2030, Minutes of Safety Meeting (Exhibit G)

2032, Monthly Plant Safety Survey (Exhibit F)

2033, Monthly Report of Contaminant Testing (Exhibit H)

LC-2680, First Report of Accident (Exhibit B)

5.18
EXHIBIT A

Case No._____ Date_____

First Aid Report

Name_____ Clock No._____ Department Plant_____

Male ☐ Female ☐ Occupation_____ Foreman_____

Date of Injury_____ Time___ a.m. p.m. Date of First Treatment_____ Time___ a.m. p.m.

Nature of Injury_____

_____

Sent: Back to Work ☐ Doctor ☐ Home ☐ Hospital ☐

Estimated Disability_____ days. Name of Witness_____

Injured's Description of Accident_____

_____

_____

Signed_____
First Aid Man or Nurse

Air Products, Inc.

Form 2019 *(Use reverse side for additional information)*

Form LIBC 344

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF LABOR AND INDUSTRY
BUREAU OF WORKMEN'S COMPENSATION
HARRISBURG, PA.

EMPLOYER'S REPORT OF INDUSTRIAL INJURY

CASE NUMBER ... ...

5.18
EXHIBIT

INSTRUCTIONS

Reports of industrial injuries must be filed with the Department of Labor and Industry within 48 hours for every injury resulting in death, and within 15 days after the date of injury for all other injuries covered by the Workmen's Compensation Act, except those resulting in disability continuing less than the day, shift or turn in which the injury was received. Every question must be answered fully. Copy of this report must be sent to your insurance carrier.

DO NOT WRITE I THIS COLUMN

EMPLOYER NC

COUNTY

INDUSTRY

DATE

HOURS WORKI

AGE

CONJ. CONDITI AND SEX

OCCUPATIO

TIME EMPLO

WAGE

AGENCY

PART

ACCIDENT TY

UNSAFE ACT

MECH. DEFE

PERSON. DEFE

NATURE

LOCATION

REPORT LA

INSURANCI

DISABILITY

PAYMENT L.

TIME LOST

WEEKS D.

COMP.

MEDICAL

OTHER

TOTAL

OCC. DIS. TY

EMPLOYING CONCERN

(1) Name ... (Give name under which concern does business) Employer or Carriers File No. ...

(2) Office address: No. and Street ... City ... County...

(3) Nature of business ... (List principal products or services of the concern)

(4) Place where accident occurred ... (City and County) (5) On Employers premises... (Yes or No)

(6) Date of accident ... (7) Hour: ... A. M. P. M. (8) Hour injured began working ...

(9) Date disability began ... (10) Was injured paid in full for the day?... (Yes or No)

INJURED EMPLOYEE

(11) Name ... (First Name) (Middle Initial) (Last Name) (Soc. Sec. No.)

(12) Address: No. and Street ... City ...

(13) Age Date of Birth ... (14) If under 18, did you have on file an employment Certificate?... (Yes or No)

(15) Number of Certificate ... (16) Occupation for which issued...

(17) Check (/) Married ... Single ... Male ... Female ... U. S. Citizen ... (18) No. children under 18 yrs...

(19) Occupation ... (20) How long employed at occupation at which injured...

(21) Number of hours worked per day ... (22) Number of days worked per week...

(23) Wages: Per Hour $ ... Per Day $ ... Per Week $ Board or Lodging...

CAUSE OF ACCIDENT

(24) What was employee doing when the accident occurred... (Describe briefly as loading truck; operating a drill press; shoveling dirt; painting with spray gun etc.)

(25) What machine, tool, substance or object was most closely connected with the accident ... (Name the machine, tool, appliance, gas, liquid, etc. involved)

(26) If machine or vehicle, what part of it ... (State if gears, pulley, motor, etc.)

(27) How did the accident happen ... (Describe the accident fully, stating whether injured person fell or was struck, etc. and all factors contributing to the accident. Use other side for additional space.)

(28) Was the machine, tool or object defective in any way? ... (29) If so, how?...

(30) Could the accident have been prevented?... (31) How?... (Specify by illuminating, ventilating, replacing, providing goggles, etc.)

(32) Were mechanical guards or other necessary safeguards (such as goggles) provided...

(33) Was injured using them?...

NATURE AND LOCATION OF INJURY OR OCCUPATIONAL DISEASE

(34) Describe in detail the nature of the injury or occupational disease, and the part of the body affected. For Example, amputation of right arm, crushing injury to chest, affected respiratory tract, skin infection, etc.)

(35) Attending physician and hospital ... (Name and address)

(36) Has employee returned to work? ... (37) If so, give date ... (38) At what weekly wage?...

(39) Did injury result in death? ... (40) If so, give date...

(41) Did the employee have the loss or loss of use of any member before accident? ... (If so, describe the part of the body affected)

INSURANCE

(42) Name of workmen's compensation insurance carrier and branch office ... HARTFORD ACCIDENT AND INDEMNITY COMPANY 7 PENN CENTER PLAZA, PHILADELPHIA, PENN. 19103

(43) Date of this report ... Made out by ...

Official position...

(See Instructions on other side)

Form I C-2850 4th Rev. Printed in U S A. 3-'58

5.18
EXHIBIT C

Air Products and Chemicals inc.

Office Use

Non-Disabling ☐

Disabling (lost-time) ☐

Supervisor Accident Investigation Report

Name of Injured_____ Clock No._____Date of Injury_____

Age_____ Length of Service: With Company_____on Present Job_____

Occupation _____

Nature of Injury _____

Description of Accident

(This information is for use in preventing similar accidents. Answer questions specifically, as indicated by example.)

1. What Job Was Employee Doing Including Tools, Machine and Materials Used? (Example: *Lifting* a heavy casting onto a *four wheel truck*.)

_____

_____

2. How Was Employee Injured? (Example: The casting *slipped* from his *grasp* and *fell* on his toes.)

_____

_____

_____

3. What Did Employee Do Unsafely? (Example: Tried to lift *too heavy load*.)

_____

_____

4. What Was Defective, In Unsafe Condition, or Wrong with Method? (Example: should have had *help*.)

_____

_____

5. What Safeguards Should Be Used? (Example: Wear *Safety Shoes*.)

_____

_____

6. What Steps Were Taken to Prevent Similar Injuries? (Example: Instructed men to assist each other in lifting heavy loads.)

_____

_____

7. What Other Steps Should Be Taken to Prevent a Recurrence? Example: Provide mechanical handling equipment for this work.)

_____

_____

_____

Signed _____

Department_____

Plant _____

(Over)

5.18
EXHIBIT C

FORM NO. 2020
(Reverse Side)

For Office Use Only

(Enter as Facts become available)

8. Temporary Total ☐	Permanent Partial ☐	Death or Permanent Total ☐
Started losing time_____	Part of Body_____	Time charge_____
Returned to work _____	Per cent loss or loss of use_____	
Time charge _____	Time charge_____	

9. Compensation $_____ Medical $_____ Other $_____

5.18
EXHIBIT D

Air Products and Chemicals INC.

NEAR ACCIDENTS
UNSAFE PRACTICES OR CONDITIONS

DATE _____

*COPY TO: Safety Department - Trexlertown

_____

PLANT _____ DEPARTMENT _____

PERSON SUBMITTING REPORT _____

WHERE THE ACCIDENT OR UNSAFE PRACTICE OCCURRED _____

DESCRIPTION OF THE EVENT OR CONDITION _____

SUGGESTION FOR CORRECTION _____

ACTION TAKEN FOR CORRECTION _____

*Copies should be directed to the Safety Department and also to the manager of the department originating the report.

Form 2023

5.18
EXHIBIT E

Air Products and Chemicals INC.

MONTHLY SUMMARY OF INJURY

To: W. L. Ball, Safety Director
Trexlertown

Location_____

Month_____

No. of Employees	Hours Worked This Month	First Aid Cases	Doctors Cases	Lost Time Cases	Days Lost	Date of Last Lost Time Accident

List all lost time cases below:

Name	Date of Injury	No. of Days Lost	Description of Accident

Note: This form must be completed and forwarded to the Safety Department in Trexlertown by the 10th day of the month following the end of the month being reported.

Signed _____

5.18
EXHIBIT F

Air Products and Chemicals INC.

MONTHLY PLANT SAFETY SURVEY

Date _____

LOCATION _____ INSPECTOR _____

	Yes	No
Steel Members (beams, columns)		
overloading	☐	☐
deflection	☐	☐
rivets in good condition	☐	☐
welds in good condition	☐	☐
Concrete Members (floors, beams, columns)		
overloading	☐	☐
cracks	☐	☐
spalling		
Wood Members (joists, beams, columns)		
overloading	☐	☐
deflection	☐	☐
cracks	☐	☐
rot	☐	☐
Masonry Walls		
settlement	☐	☐
cracks	☐	☐
loose coping	☐	☐
Flooring		
holes	☐	☐
worn surfaces	☐	☐
slippery surfaces	☐	☐
openings guarded	☐	☐
Roofs		
good anchorage	☐	☐
leakage	☐	☐
good condition	☐	☐
loose material on roofs	☐	☐
good drainage and open drains	☐	☐
Stairways		
tread and risers good	☐	☐
hand rails good	☐	☐
well-lighted	☐	☐
fire enclosures and doors work properly	☐	☐
storage of material on or under stairs	☐	☐
Steam Boiler and Other Heating		
maintenance good	☐	☐
water feed supply good	☐	☐
relief pressure control	☐	☐
pressure apparatus inspected	☐	☐
burnable material away from heating unit and smoke pipe	☐	☐
Lighting		
general lumination good	☐	☐
glare	☐	☐
color good	☐	☐
maintenance good	☐	☐
shadows on work	☐	☐
Fire Doors		
overhead track clean	☐	☐
operating mechanism good	☐	☐
fusible links good	☐	☐
doors blocked	☐	☐

	Yes	No
Cranes, Hoists		
overloading	☐	☐
deterioration	☐	☐
controls function properly	☐	☐
electrical safeguards	☐	☐
condition of cables good	☐	☐
condition of pins good	☐	☐
condition of hooks good	☐	☐
rail end stops provided	☐	☐
footwalks, ladders, safety appliances good	☐	☐
Ventilation		
spray booths good	☐	☐
dip tanks good	☐	☐
degreasers good	☐	☐
metal hardening good	☐	☐
solvent handling good	☐	☐
Elevators		
operating mechanism good	☐	☐
cables good	☐	☐
machinery good	☐	☐
overloading	☐	☐
any shear hazard	☐	☐
Electrical		
transformers good	☐	☐
switchboards good	☐	☐
wiring good	☐	☐
outlets good	☐	☐
protective grounds checked	☐	☐
extension cords good	☐	☐
portable lights good	☐	☐
sufficient outlets	☐	☐
fuse boxes locked	☐	☐
fuses good	☐	☐
Sprinklers		
air pressure (dry system) correct	☐	☐
water pressure correct		
all control valves open	☐	☐
water systems heated to at least 40 degrees	☐	☐
stored material too close (36" below pipe)	☐	☐
sprinkler systems operative	☐	☐
Standpipes and Hose		
hose attached to each outlet	☐	☐
nozzle attached	☐	☐
properly racked	☐	☐
condition good	☐	☐
Extinguishers		
did you examine each unit	☐	☐
all have seals	☐	☐
all currently dated	☐	☐
any need refilling	☐	☐
all units accessible	☐	☐
all in good condition	☐	☐

Form 2032

5.18
EXHIBIT F

FORM 2032
(Reverse Side)

Housekeeping	Yes	No
aisles good	☐	☐
stairs good	☐	☐
floors good	☐	☐
material storage good	☐	☐
waste disposal good	☐	☐
wash and locker rooms good	☐	☐
outside areas good	☐	☐
basement good	☐	☐
explosive materials properly handled and stored	☐	☐
Cylinders		
all cylinders segregated	☐	☐
all cylinders supported or tied in	☐	☐
caps on all unused cylinders		
Elevated Runways and Platforms		
in good condition	☐	☐
clear of obstructions	☐	☐
handrails good	☐	☐
toeboards good	☐	☐
Fire Exits		
panic hardware operative	☐	☐
clear of material	☐	☐
clearly marked	☐	☐

Smoking	Yes	No
do employees understand smoking rules	☐	☐
any evidence of smoking in restricted areas	☐	☐
Personal Protective Equipment		
all gas masks properly stored	☐	☐
are they clean	☐	☐
all air packs properly stored	☐	☐
are they clean	☐	☐
are air pack cylinders full	☐	☐
do air packs have alarms	☐	☐
extra gas mask canisters and air pack cylinders properly stored	☐	☐
all first aid kits full and clean	☐	☐
extra first aid kits stored	☐	☐
are hard hats clean	☐	☐
are dust masks clean	☐	☐
are safety goggles in good repair and clean	☐	☐
have electrical gloves been tested	☐	☐
are welders hoods in good condition	☐	☐

HOSE HOUSES

Each Hose House Inspected _____ Any Obstructed _____ Do Hydrants Drain Properly _____

Hose House No.	No. Ft. Hose	No. Nozzles	No. Bars	No. Lanterns	No. Spanners	No. Wrenches	Other	Arrg'd. OK	Hose House No.	No. Ft. Hose	No. Nozzles	No. Bars	No. Lanterns	No. Spanners	No. Wrenches	Other	Arrg'd. OK
1									7								
2									8								
3									9								
4									10								
5									11								
6									12								

COMMENTS AND RECOMMENDATIONS

S.1C
EXHIBIT G

Air Products and Chemicals INC.

Minutes of Safety Meeting

Location _____
Plant No. _____
Date of Meeting _____

Distribution: W. L. Ball _____ _____
E. J. Donley _____ _____
L. P. Pool _____ _____

Attendance:

_____ _____ _____ _____
_____ _____ _____ _____
_____ _____ _____ _____
_____ _____ _____ _____

Discussion:

New Recommendations: (list numerically with year as prefix)

Action taken on Previous Recommendations

By _____

2030

5.18
EXHIBIT

AIR PRODUCTS AND CHEMICALS, INC.

Location----------

Date----------

Monthly Report of Contaminant Testing

Distribution:

_____ - Safety Department

_____ - _____Regional Operations Manager

_____ - Operations Dept. Manager

_____ - Regional Safety Supervisor/Engineer

	Plant No.					
Total Hydrocarbons						
Required:						
1. Reboiler Liquid or L.P. Column Sump (V-___)						
Maximum.						
Average.						
2. Oxygen Product (O_2 Pass H. E. or LOX Transfer Tank (V-___)						
Maximum.						
Average.						
Optional:						
3. Upstream of Guard Adsorber (V-___)						
Maximum.						
Average.						
4. Downstream of Guard Adsorber (V-___)						
Maximum.						
Average.						
5. Air to Column (V-___)						
Maximum.						
Average.						
6. Crude Oxygen Upstream of H.C. Adsorbers (V-___)						
Maximum.						
Average.						
7. Crude Oxygen Downstream of H.C. Adsorbers (V-___)						
Maximum.						
Average.						
Notes:						
1. Fill in valve nos. where samples are taken.						
2. Take samples as required and applicable to the particular plant.						
Acetylene (N-Negative: P-Positive)						
1. Reboiler Liquid or L.P. Column Sump.						
2. Storage Tanks.						
REMARKS - (Give date and details if positive):						
Cold Box Atmosphere						
. List any concentration over 21% or a significant increase over a previous reading. Indicate source of abnormal concentration listing corrective action.						
1. Column Box (integral separator box).						
2. Heat Exchanger Box						
3. Pump Box (Plant or Storage).						
4. Liquid Storage Box						

See Plant Operations Manual, Section 5.18 for details on reporting requirements.

Form No. 2033
4/26/67

Submitted By

AIR PRODUCTS AND CHEMICALS, INC.

DRAWING 58521 C, REVISION B

OXYGEN PUMP FILTER ASSEMBLY
DECEMBER 18, 1957

DOCUMENT NOT AVAILABLE FOR GENERAL DISTRIBUTION

APCI DOCUMENT
NO. 11000234

Air Products and Chemicals INC.

COMPRESSED VALVE CYLINDER VALVE

OUTLET AND INLET CONNECTIONS

by

Compressed Gas Assoc.

CGA Pamphlet, Volume
1, 57P, 1965

APCI DOCUMENT
NO. 99000235

Air Products and Chemicals INC

COMPRESSED GAS CYLINDER VALVE OUTLET AND INLET CONNECTIONS

by

Compressed Gas Association

ASA-B57.1, 57P,

1965

APCI DOCUMENT
NO. 99000236

Air Products and Chemicals INC

COMPRESSED GAS CYLINDER VALVE

OUTLET AND INLET CONNECTIONS

by

Compressed Gas Association

Canadian Standards
CAS-B96 57P, 1965

APCI DOCUMENT
ID 22000232

FILLING PROCEDURE FOR TRANSPORTABLE CRYOGENIC CONTAINERS
(250 - GALLON CAPACITY OR LARGER) - GENERAL
This procedure is similar to Section 9.1 District Operations Manual

I. PURPOSE

To establish a standard procedure to be used at APCI facilities for bulk loading (filling) cryogenic containers with conventional product for shipment to other APCI facilities or to commercial customers.

II. RESPONSIBILITY

Plant managers and operating personnel whose duties include any aspect of product filling are responsible for compliance with the provisions of this procedure as applicable.

III. PROCEDURE

A. Scope

This procedure applies to all districts except thos specifically excluded by the Technical Director of the Industrial Gas Divi-ion. Its use is limited to the filling of containers having a capacity of 250 gallons or larger with conventional liquefied industrial gases (nitrogen, argon and oxygen).

This procedure does not include detailed filling instructions for specific containers (tanks, railroad cars, pumpers, etc.)

Valve identification numbers, loading limits and customer purity requirements do not appear herein.

The intention of this procedure is to ensure product quality and proper labeling of product containers. This procedure does not nullify or supersede the authority for loading cryogenic containers. This authority is defined in Procedure No.01.05.02 of the Standard Procedure - Management Manual.

B. Preparation

After Operations personnel have established that a particular container is scheduled for loading, prepare for the loading as follows:

1. Loading personnel shall be certain that pads used for loading liquid oxygen containers are clean and free of oil deposits, rags, paper and other litter.
2. The tank trailer, pumper, or other transportable container shall be properly positioned on the pad. After positioning, at least one rear wheel shall be chocked.

APCI DOCUMENT NO. 99000238

FILLING PROCEDURE FOR TRANSPORTABLE CRYGOENIC CONTAINERS
(250 - GALLON CAPACITY OR LARGER) - GENERAL
This procedure is similar to Section 9.1 District Operations Manual

3. Vehicle engines shall be shut down before loading begins and shall not be restarted until the loading has been completed, the hoses have been disconnected and the loading area is considered safe for engine startup and vehicle removal.

   Caution: When LOX tankers are being filled, oxygen vapors vent into the immediate area and oxygen-rich atmospheres can develop. Such atmospheres, often indicated by heavy frost vapors, accentuate the hazard of any combustion that might occur. It is therefore important not to start vehicle engines until a safe atmosphere is assured. Moderate prevailing winds and an absence of frost vapors indicate that high concentrations are not present. Use a Beckman D-2 or similar analyzer to check the percentage of oxygen in the surrounding atmosphere (21 percent is normal). Oxygen concentration should never exceed 25 percent; if it does, do not start vehicle engines.

   a. At locations where <u>drivers</u> are responsible for loading, the driver shall remove the ignition keys from his vehicle and keep them in his possession until conditions permit safe removal of the loaded container.

   b. At locations where <u>loaders</u> are responsible for loading, the loader shall place a red flag standard (at least one per vehicle) directly in front of the vehicle being loaded. The red flag shall be clearly visible from the drivers's seat. If the towing vehicle has been disconnected from the container, the standard positioned so that it must be moved before the container can be removed. The loader shall not remove the flag standard until it is safe to move the loaded container.

   c. Whenever a "foreign" (i.e. non-APCI) driver enters APCI property, he shall be required to check in with the plant manager or his designated loading supervisor. Foreign drivers are not to load their own equipment. If they insist, they can do their loading with an APCI employee observing the procedures and operating all valves on APCI equipment.

4. Operations personnel shall visually check the load and unload connections on the transportable container to be certain that end connections are correct for the product being loaded.

FILLING PROCEDURE FOR TRANSPORTABLE CRYOGENIC CONTAINERS
(250-GALLON CAPACITY OR LARGER) - GENERAL

This procedure is similar to Section 9.1 District Operations Manual

Note: The operator or loader shall be certain that "fixed ends" attached to the loading and unloading line and pump discharge line are correct for the product being loaded and that all hoses ends on transfer hoses stored in the transportable container's storage compartments are correct for the product it will contain. Product will not be loaded into containers with improper "fixed ends" or into containers that carry transfer hoses with improper hose ends. The use of adapters to accomodate loading through an incorrect "fixed end" is strictly prohibited except when loading customer-owned bulk delivery vehicles. In such cases, any type of adapter may be used for loading provided one end of the adapter is different from APCI's standard LOX or LIN-LAR fittings. If it is ever necessary during the loading of a "foreign" vehicle to use an adapter that would permit different types of APCI product fittings to be interconnected, the adapter must be kept in custody of the plant manager or his delegated representative (under lock and key) except when in use.

a. Exhibit A provides detailed information on container fixed ends and hose ends that are IGD-approved for use in oxygen, nitrogen and argon service.

5. A visual check shall be made of the control equipment on the container. Control compartments of containers to be filled with oxygen must be free of rags, papers, soiled gloves, etc. Cold piping will require occasional steam deicing to render valves and controls accessible and operable.

Note: The visual inspections required in 4 and 5, above, shall be performed before loading. The containers may have been positioned by drivers of previous work shifts, or the container may have been tagged to indicate that some of its equipment was in need of checkout, repair or replacement.

6. The loader shall also be assured that all of the signs and markings on the vehicle will name one product only (the product being loaded).

7. Before loading, any container scheduled to be loaded shall have its residual contents sampled and analyzed for impurities. See procedure 2.05 for details. Whenever the analysis of the residual contents of a tanker or railroad car indicates that the product does not meet product specifications, the plant superintendent shall be contacted immediately. It shall be his decision, with appropriate guidance from local or regional distribution management, to determine if it is appropriate to purge, repair, or modify the unit before refilling. Some factors to be considered are:

FILLING PROCEDURE FOR TRANSPORTABLE CRYOGENIC CONTAINERS
(250 - GALLON CAPACITY OR LARGER) - GENERAL

a. The degree of impurity that can be tolerated in a container before loading will vary with the amount of residual liquid, the degree of contamination in the residual liquid, and the purity and quantity of liquid to be added. Since all three factors may vary from one container to another, it is impossible to publish meaningful criteria.

b. Serious evaluation must be made of the possible end result (product purity after loading). It is possible for the degree of impurity in the residual liquid to exceed the limits of IGD Product Purity Specifications (section 2.03.02), and still be well within the limits after loading, since the degree of impurity will diminish as high-purity liquid product is added.

c. At no time shall product that is below IGD Product Purity Specifications (section 2.03.02) be loaded into containers for shipment.

Exception: In some cases, intradistrict shipments may be made to other APCI facilities for further purification. (Crude argon, etc.)

8. When filling a customer vehicle that does not contain a sample tag or when the customer does not want his product analyzed, APCI shall perform analysis to verify product quality being loaded. Samples should be taken either from a sample tap in the APCI fill line or in the storage tank off-loading manifold. Analytical data shall be recorded on form 3096 (see exhibit B).

9. Loading personnel shall be certain that all necessary preliminary safety measures have been taken.

C. Filling

1. The container to be filled shall be coupled to the facility's cryogenic storage tank and filled according to standard purge and fill procedure applicable to the particular container. The container's flash vent shall be used.

a. The Operator shall visually inspect the condition of the fill equipment each time a container is filled. Any irregularities must be examined in detail.

Note: Transfer hoses must be in good condition and must be dust-capped when not in use. They shall not be left on pads where they could be damaged by dragging or by trailers running over them. Fill fittings and unions must be free from deep nicks or scores. Oxygen, nitrogen, and argon transfer connections must also be dust-capped except when in use.

FILLING PROCEDURE FOR TRANSPORTABLE CRYOGENIC CONTAINERS
(250 - GALLON CAPACITY OR LARGER) - GENERAL

b. Flash-vapor recovery systems, which are installed at certain APCI facilities, can be used only when the container's residual liquid meets IGD Product Purity Specifications. Such recovery systems are also undersirable for certain other reasons, therefore their use shall depend on the policy of the facility and requires approval of the Technical Director, IGD.

2. After filling, the container contents must be sampled and analyzed again. See procedure 2.05 for details. Results shall be recorded on form 3096 (see exhibit B) and on tag form P-L Tag No. 1 (see exhibit C). The tag shall be filled out in detail and attached securely to the container product drain (outlet, unloading, or discharge valve).

a. Product purity must meet the requirements of the applicable IGD Product Purity Specifications (section 2.03.02) before its release for shipment to customers.

Exception: Certain intradistrict shipments of product which does not meet the above mentioned purity specifications may be made to other APCI facilities for further purification. (Crude argon, etc.)

b. Drivers of customer-owned vehicles that do not require product purity analysis shall be required to sign APCI's purity analysis sheet (form 3096, exhibit B), verifying the product and the purity of the product received.

D. Railroad Car Shipments

Any liquid product shipped in railroad cars shall be accompanied by the following special forms:

1. Tank Car Loading and Receiving Report, form 3111-A (see exhibit D).

Three copies shall be used. The original and the third copy, with with parts I and II filled out, shall accompany the railroad car, and the second copy shall remain at the filling facility. When the railroad car reaches its destination, part III of the form shall be filled out, and both copies shall be forwarded to Air Products and Chemicals, Inc., P.O. Box 538, Allentown, Pennsylvania 18105 - Attn: H. Hansen.

2. Unloading Report and Instructions for Empty Tank Car Forwarding form 3101 (see exhibit E).

Three copies shall be used. The original copy shall be retained by the agent. The second copy shall be mailed to Air Products and Chemicals, Inc., P.O. Box 538, Allentown, Pennsylvania 18105 - Attn: H. Hansen. The third copy is for the facility file.

FILLING PROCEDURE FOR TRANSPORTABLE CRYOGENIC CONTAINERS
(250 - GALLON CAPACITY OR LARGER)- GENERAL

E. Labeling

Product Labeling Tag, form P-L Tag No. 1 (see exhibit B) shall be used to label all bulk shipments before they are released to the customer. The tag shall be filled out in detail as follows:

1. Name of the facility where the container was loaded.
2. Name of theproduct in the container.
3. Description of the container (tanker, trailer, railroad tanker, pumper, etc.) and its identification number.
4. Product purity in the container.
5. Amount of impurities, e.g., dewpoint, ppm oxygen in nitrogen or argon, total hydrocarbons in oxygen (when this is required to meet particular customer specifications.)
6. Total quantity of product in the container. (This entry may be omitted and is not to be used for billing).
7. Date and time the container was filled and the signature of the person who filled it.

Note: Analysis (purity and impurities) shall be performed on the product in the bulk container, not on the product used to fill it. Use cryogenic samplers if necessary.

F. Check Lists (Exhibits F and G)

1. Railroad Tanker Filling and Highway Tanker Filling Check Lists (Form 3622 and 3623) are to be utilized for each container filled.

2. The check lists are summaries of above procedures. They are of necessity concise and are not intended to replace the procedures but to serve as a reminder to personnel to complete all items. Loading personnel must be familiar with the contents of this procedure to load equipment and use the check list.

3. Check lists are also to serve as a means of "passing the word" to the next shift, where applicable. Each item completed shall be initialed and the list passed on to the relieving loader.

4. The tanker number and date are to be filled in and the form assigned to the tanker when it arrives in the loading area. It shall be kept convenient (Examples: rear of trailer compartment or load area analyzer house) so it can be initialed as work is completed. Clipboard arrangements with hooks at individual load stations are ideal except during inclement weather. The assigned form is not to be removed from the area until it has been completed and the Product Label is attached to the trailer. The completed form shall be kept for at least one month after which time it can be discarded.

FILLING PROCEDURE FOR TRANSPORTABLE CRYOGENIC CONTAINERS
(250 - GALLON CAPACITY OR LARGER) - GENERAL

5. The purity data section will require fill in on one line (two for LAR) under each of the "Residual" and "Load" columns indicating purity analysis before and after filling. The type analyzer to be used for each product is listed to guide personnel on the proper instrument to be used. This is particularly important for new personnel and those helping in an interim basis for emergencies or "fill in" for loaders absent.

IV. RELATED PROCEDURES

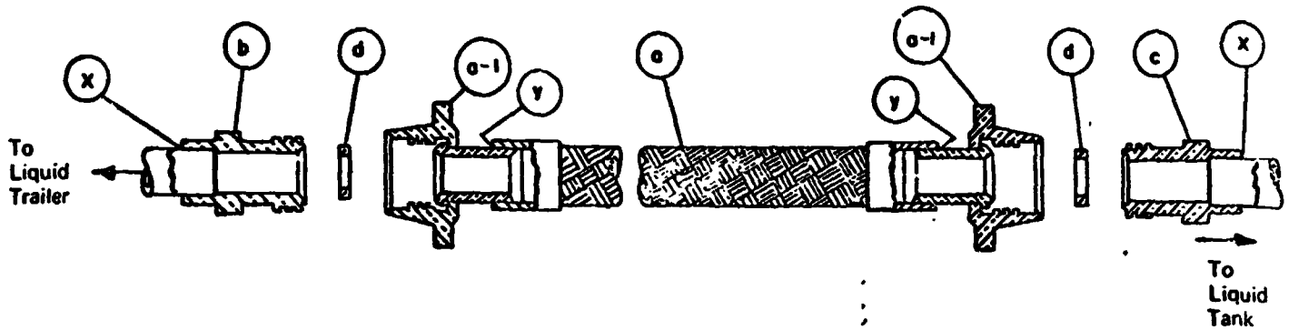
2.02.01 (and following) - Specific Facility Loading Procedures
2.05 - LOX, LIN LAR Shipment Sampling and Analysis.

V. RELATED FORMS

Exhibit A - Standards for Liquefied Gases Transfer Hoses & Connections
3096 Rev. 7-65 - Product Analysis, exhibit B.
P-L Tag No. 1 - Product Labeling Tag, exhibit C.
3111-A - Tank Car Loading Shipping and Receiving Report, exhibit D.
3101 - Unloading Report and Instructions for Empty Tank Car Forwarding, exhibit E.
3622 - Railroad Tanker Filling Check List, exhibit F
3623 - Highway Tanker Filling Check List, exhibit G

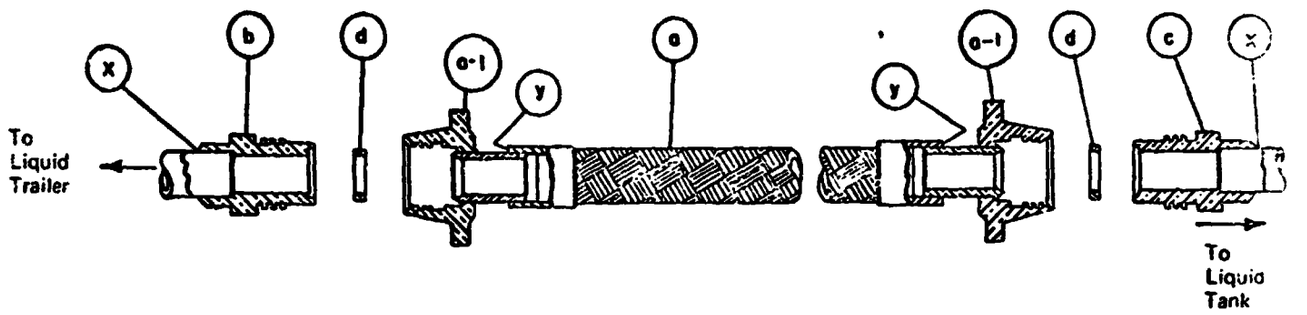
STANDARDS FOR LIQUEFIED GASES TRANSFER HOSES AND CONNECTIONS

OXYGEN



Size:		3"	1½"
Use:		Pressure Transfer	Pump Transfer
Maximum Working Pressure:		50 PSIG	300 PSIG
APCI Part Numbers:			
(a)	Transfer Hose Assembly:	62917A (3-421-69-0002)	62916A (3-421-69-0003)
	(a-1) Hose Union Assembly:	62766C (3-916-17-0007)	62768C (5-916-17-0006)
(b)	Trailer Adapter Assembly:	62763C (5-916-17-0002)	62755C (5-916-17-0003)
(c)	Tank Adapter Assembly:	62763C (5-916-17-0002)	62755C (5-916-17-0003)
(d)	Gasket:	62744A (4-372-03-0028)	62751A (4-372-03-0029)
Pipe Connections	(x):	3-1/8" O.D. Female Sweat	1-5/8" O.D. Female Sweat
	(y):	3" NPT	1½" NPT

NITROGEN & ARGON



Size:		3"	1½"
Use:		Pressure Transfer	Pump Transfer
Maximum Working Pressure:		50 PSIG	300 PSIG
APCI Part Numbers:			
(a)	Transfer Hose Assembly:	62918A (3-421-69 0004)	62935A (3-421-69-0005)
	(a-1) Hose Union Assembly:	62761C (5-916-17-0008)	62774C (5-916-17-0001)
(b)	Trailer Adapter Assembly:	62748C (5-916-17-0004)	62771C (5-916-17-0005)
(c)	Tank Adapter Assembly:	62748C (5-916-17-0004)	62771C (5-916-17-0005)
(d)	Gasket:	62744A (4-372-03-0028)	62751A (4-372-03-0029)
Pipe Connections	(x):	3-1/8" O.D. Female Sweat	1-5/8" O.D. Female Sweat
	(y):	3" NPT	1½"

NOTES: *All hoses are 10 feet long.*
All hose end connections have dust plug and chain assembly.
All male adapter assemblies have dust cap and chain assembly.
All above items stocked by Parts Department under code numbers shown in parenthesies.
Part Nos. (a-1) and (a-2) hose union assemblies are actually subassemblies of complete hose assemblies (a).

Section 2.02
Exhibit B

Air Products and Chemicals INC.

INDUSTRIAL GAS DIVISION

PRODUCTS ANALYSIS: Ultra high purity Argon, Puragon, Helium, High purity Hydrogen
Ultra high purity Hydrogen, High purity Nitrogen, Ultra high purity Nitrogen, Oxygen

Form 3096 Rev. 3
1-19-65 LCK

District_____ Month of_____

DATE	CYL, TANKER, OR TRAILER NUMBER	PRES. PSIG	GAS PURITY MOL %	OXYGEN PPM	DEW POINT °F	REMARKS

Section 2.02
Exhibit C

Air Products and Chemicals INC.

FACILITY_____

PRODUCT_____

CONTAINER TYPE & No._____

QUANTITY LOADED_____ (FT^3, LBS, GALS, ETC)

PURITY_____ %

IMPURITIES:_____ $PPMO_2$

DEW-POINT_____ H_2O

_____ OTHER

DATE_____ _____ OTHER

OPERATOR_____

P-L TAG No. 1

NOTE: This tag can be obtained from APCI Spare Parts Department at Allentown, Pa. by requesting APCI Stock Code Number 4-847-51-0020.

Section 2.02
Exhibit D

Car No.....

Air Products and Chemicals INC.

ALLENTOWN COPY-1

(Compartment: .....Large.....Small)

TANK CAR LOADING, SHIPPING AND RECEIVING REPORT

PART I

Car as received empty: (Date readings taken.....)

1. Last contents..... Gas Analysis.....
   Liquid Analysis.....
2. Pressure (PG 1).....psi (PG 2).....psi
3. Liquid Level (LLG).....inches
4. Vacuum Reading.....microns Reading Taken at.....o'clock Ambient Temp.....°F.
5. Note here any valves left open, loose caps, missing gaskets or any other mishandling by consignee.....
   .....
6. What repairs were made to prepare car for loading (include pumping of vacuum, purging, etc.):.....
   .....
7. Report prepared by.....

PART II

Final check of loaded car:

1. Contents..... Date Shipped..... 2. Pressure (PG 1).....psi
   (PG 2).....psi
3. Liquid Level (LLG).....inches 4. Vacuum Reading.....microns
5. Gas Analysis..... 6. Liquid Analysis.....
7. Valves Checked by.....
8. Locks / Seals applied by.....
9. Commodity sign OK..... 10. Any evidence of cold spots.....
11. Car OK'd for shipment by..... Date .....

PART III

Receiving Report at Destination:

1. Pressure (PG 1).....psi (PG 2).....psi 2. LLG.....in. loaded;.....in. empt
3. If evidence of loss enroute is detected, describe here.....
   .....
4. Analysis OK..... 5. Seals intact.....Yes .....No
6. Estimated transfer losses.....scf determined by.....weight
   .....LLG
   .....other
7. Appearance on arrival.....
8. Checked by..... Date.....

Form No. 3111-A Rev. 11-29-63

Air Products and Chemicals INC.

Section 2.02
Exhibit E

UNLOADING REPORT AND INSTRUCTIONS FOR EMPTY TANK CAR FORWARDING

For Car. . . . . Shipped. . . . . 19. . . .

TO CUSTOMER:

As soon as this car has been unloaded, please notify the railroad agent by phone and (after filling in lines 1, 2, 3 & 4) present this set of forms to the railroad agent for his signature. The signed original is to be retained by the agent, the duplicate mailed immediately to Air Products & Chemicals, Inc., P. O. Box 538, Allentown, Pa., and the Triplicate is for your file.

Line 1 Loaded car arrived (Date) . . . . . (Hour). . . . . .

Line 2 Car Spotted at unloading position (Date). . . . . (Hour). . . . . .

Line 3 Reported to RR as empty (Date). . . . . (Hour). . . . . .

Line 4 Car removed from siding (Date) . . . . . (Hour). . . . . .

All covers and unloading valve plugs and caps must be in place and properly secured before cars are turned over to the railroad for movement empty. Please observe all additional unloading instructions on the car. Thank you.

TO FREIGHT AGENT,. . . . . RR.

. . . . . .

This car is now empty and ready to be forwarded, free on mileage equalization,
To:

. . . . . .

. . . . . .

. . . . . .

Routing instructions must be strictly observed.

Car Initial & Number	Last Contents

Route via . . . . . .

. . . . . .Shipper . . . . . RR Agent

By . . . . . By . . . . . .

NOTE: The prompt unloading and return movement of this car is absolutely necessary to assure the reliable service we all expect. Your cooperation is appreciated.

REPRODUCIBILITY OF THE ORIGINAL COPY IS POOR

Section 2.02
Exhibit F

RAILROAD TANKER FILLING CHECK LIST

Facility _____ Date _____

APCI Tank No. _____ or Customer _____ No. _____

Residual Quantity _____		Depressure, disconnect, cap & rack hose	____
Spot, set brakes, check both direction	_____	Load purity - Fill in below	____
Complete Part I, Form 3111A	_____	Disconnect sample line, cap or purge	____
Install derail and flag	_____	Final check for valve settings	____
Residual purity - Fill in below	_____	Final check for maintenance necessary	____
Check for maintenance necessary	_____	Complete Part II, Form 3111A	____
Proper prouuct signs or decals	_____	Complete & attach Prod. Labeling Tag	____
Proper fixed ends, tanker and hoses	_____	Close fill compartment and seal	____
Fill tanker according to procedures	_____	Full quantity _____	____

PURITY DATA

PROD.	Sample	Residual		Load	Type Analyzer to be Used
LAR	Vapor Source	_____	ppm N_2	_____	Ion Mobility
	*Liquid Source	_____	ppm O_2	_____	Electrochemical
LIN	*Liquid Source	_____	ppm O_2	_____	Electrochemical
LOX	Vapor Source	_____	% O_2	_____	Orsat or Paramagnetic

* is sample to be taken at one of the two small (usually 1/2") liquid drain valves at each end the car. Record full purity (ppm or % of O_2, N_2, or Ar) purity similar to analysis above using the same type analyzer. Purity _____.

NOTES

1. The tanker number and date is to be filled in and this form assigned to the tanker when it arrives in the loading area. It shall be kept convenient (back of trailer or load area analyzer house) so it can be initialed as work is completed. Remove this form after the Product Labeling Tag is attached and keep on file for a one month period.

2. Instruments utilized must indicate on charts, they have been spanned (and zeroed where applicable) within the last 24 hours or they must be checked before analytical procedures.

3. Vapor source samples must flow for at least 5 minutes before introduction into analyzer. Liquid source must flow for at least one minute. Use some descretion on long sample tube runs.

4. Refer to POM procedure 2.05 for particulars on sampling, analysis and analyzers, procedure 2.02 for filling and 1.17 (or Operations Safety Manual) for safety rules on liquid handlin

REMARKS

Section 2.02
Exhibit G

HIGHWAY TANKER FILLING CHECK LIST

Facility _____ Date _____

APCI Tanker No. _____ or Customer _____ No. _____

Residual Quantity _____	_____	Depressure, disconnect, cap & rack hose	_____
Spot against bumper	_____	Load purity - Fill in below	_____
Turn off ignition, remove keys	_____	Disconnect sample line, cap or purge	_____
Chock in front of rear wheels	_____	Final check for valve settings	_____
Flag in front of vehicle	_____	Final check for maintenance necessary	_____
Residual purity - Fill in below	_____	Complete & attach Product Labeling Tag	_____
Check for maintenance necessary	_____	Close and latch rear doors	_____
Proper product signs or decals	_____	Log data on form 3096 and log book	_____
Proper fixed ends, tanker & hoses	_____	Full quantity _____	_____
Fill according to procedures	_____		

PURITY DATA

Prod.	Sample	Residual		Load	Type Analyzer to be Used
LAR	Vapor Source	_____	ppm N2	_____	Ion Mobility
	Liquid Source	_____	ppm O2	_____	Electrochemical
LIN	Liquid Source	_____	ppm O2	_____	Electrochemical
LOX	Vapor Source	_____	% O2	_____	Orsat or Paramagnetic

NOTES

1. The tanker number and date is to be filled in and this form assigned to the tanker when it arrives in the loading area. It shall be kept convenient (back of trailer or load area analyzer house) so it can be initialed as work is completed. Remove this form after the Product Labeling Tag is attached and keep on file for a one month period.

2. Instruments utilized must indicate on charts, they have been spanned (and zeroed where applicable) within the last 24 hours or they must be checked before analytical procedures.

3. Vapor source samples must flow for at least 5 minutes before introduction into analyzer. Liquid sources must flow for at least one minute. Use some descretion on long sample tube runs.

4. Refer to PCM procedure 2.05 for particulars on sampling, analysis and analyzers, procedure 2.02 for filling and 1.17 (or Operation Safety Manual) for safety rules on liquid handling.

REMARKS

FILLING PROCEDURE FOR TRANSPORTABLE CRYOGENIC CONTAINERS (250 Gallon Capacity or Larger)

Index to Contents

Par. 1....Purpose
Par. 2....Scope
Par. 3....Authority
Par. 4....Preparatory
Par. 5....Filling
Par. 6....Labeling

SEP 28 1971
R & D DEPT.

1. PURPOSE

This specification outlines the procedure to be employed at APCI facilities for bulk loading (filling) cryogenic containers with conventional product for destination to other APCI facilities or commercial customers.

2. SCOPE

(a) This specification shall be jurisdictive as applicable to all districts unless specifically excluded by the Facilities Operations Manager of the Industrial Gas Division.

(b) Usage of this specification is limited to the conventional industrial gases (nitrogen, argon, and oxygen) normally dispensed by districts as bulk liquid into containers of 250 gallon capacity or larger.

(c) This specification does not provide detail fill-instructions for any specific tank, pumper, railroad car, etc. No valve identification numbers, loading limits, customer purity requirements, etc. will be listed herein.

3. AUTHORITY

Procedure No. 01-05-02 of the Standard Procedure - Management Manual defines the authority for loading cryogenic containers. This specification does not preclude that authority, but is a procedure to assure product quality and proper labeling of product containers.

APCI DOCUMENT NO. 99000239

4. PREPARATORY

Prior to filling any cryogenic container (either APCI owned, leased, or customer owned) the facility's operations personnel will first check the loading schedule to determine if the container has been scheduled for loading. When it is established that a container is to be loaded, the necessary pre-fill operations will be performed in accordance with the following:

4.1 Pads utilized for spotting and loading oxygen containers shall be kept clean and free of oil deposits, rags, paper, and other litter debris.

4.2 The tank-trailers, pumpers, or other transportable containers shall be spotted on the pad in a manner which will permit utilizing the facilities provided by the pad to accommodate accidential spillage, during subsequent filling.

4.3 The transport-vehicle engines must be shut-down prior to proceeding with container loading. The engines should not be restarted until after completion of loading and hose disconnection. Engine start-up should be prohibited until such time as the area and conditions surrounding the vehicle may be considered "SAFE" for engine start-up and vehicle removal. See "CAUTION" below:

(a) At location(s) where drivers are responsible for loading. The driver shall remove the ignition keys from the vehicle and shall retain them in his possesion until conditions permit safe removal of the loaded container.

(b) At location(s) where loaders are responsible for loading. The loader shall place a red-flag standard (minimum of one per vehicle) directly in front of the vehicle being loaded. The red-flag standard must be placed in a manner so that flag is clearly visable from the driver-position inside the vehicle cab. In cases where the tow-vehicle has been uncoupled, the red-flag standard shall be so placed that the transportable container cannot be moved without first relocating the flag-standard. The loader should not remove the flag-standard until conditions permit safe removal of the loaded container.

CAUTION

When LOX tankers are being filled, oxygen vapors vent into the immediate area. Heavy frost vapors are an indication that oxygen enriched atmospheres are possible.

Oxygen enriched atmospheres increase the hazard of combustibility in the event material is ignited in the area. There-

— fore, it is important that vehicle engines are not started until it is ascertained that oxygen enriched atmospheres are not present.

Lack of frost vapors and moderate prevailing winds are indications that oxygen enriched vapors do not exist. If the vapor plume extended to the tractor during loading, the atmosphere under the hood should be checked with a Beckman D-2 or similar analyzer to determine if 21% oxygen (normal) is present. Do not start the vehicle engine if the oxygen content exceeds 23%.

4.4 The operations personnel will perform a visual check of the transportable container's load and unload connection (s) to assure proper end-connection for the product being loaded. See note below. A visual examination of condition of the transportable container's control equipment shall also be made prior to proceeding with product loading.

NOTE

THE OPERATOR OR LOADER SHALL MAKE CERTAIN THAT "FIXED-ENDS" ATTACHED TO THE LOADING AND UNLOADING LINE AND THE PUMP-DISCHARGE LINE ARE PROPER FOR THE PRODUCT BEING LOADED. THE USE OF ADAPTERS TO ACCOMMODATE LOADING OF APCI EQUIPMENT THROUGH AN INCORRECT "FIXED-END" IS STRICTLY PROHIBITED.. LOADERS SHOULD ALSO BE ASSURED THAT ALL HOSE-ENDS ON TRANSFER HOSES STORED IN THE TRANSPORTABLE CONTAINER'S STORAGE COMPARTMENTS ARE PROPER FOR THE PRODUCT IT WILL CONTAIN. PRODUCT WILL NOT BE LOADED INTO APCI CONTAINERS WITH IMPROPER FIXED-ENDS, OR CONTAINERS WHICH CONTAIN TRANSFER HOSES WITH IMPROPER HOSE-ENDS.

4.4.1 Exhibit "C" of this section depicts and provides detailed information on container fixed-ends, and hose-ends which are approved (proper) for use in product service (Oxygen, Nitrogen, Argon, and Crude Argon) covered by this section.

4.4.1.1 Rail-cars are fitted with 3" connections. The fixed-ends are depicted by items (b) and (c) of Exhibit "C". Rail-cars must have the proper fixed-ends for the product being loaded.

4.4.2 The loader should also be assured that all of the vehicle placarding will name one product only (the name of the product being loaded).

4.4.3 The visual inspections directed by the above shall be performed prior to the loading since the container may have been spotted by drivers of previous work shifts, or the container may have been tagged to indicate certain equipment to be in need of check-out, repairs, or inoperable.

4.5 The control compartments of containers to be filled with oxygen must be free of rags, papers, soiled gloves, etc. The cold piping will require an occasional de-icing (steam-off) in order to render valves and controls accessible and operable.

4.6 All containers to be loaded will have residual contents sampled and analyzed for impurities, prior to loading (See Sec. 6.3.1). Any sample analysis yielding impurities in amounts excessive of the maximum permissable impurity limitations established by I.G.D. Product Specifications (Section 10, District Operations Manual) will temporarily detain loading until an evaluation can be made with regard to the following:

(a) The specific amount of impurities which can be tolerated in a cryogenic container prior to loading will vary dependent on the amount of liquid remaining in the container, the degree of contamination in the residual liquid, and the purity and amount of liquid to be added during loading. Since these factors may vary from one container to another, it is impossible to list such criteria herein.

(b) It should be realized the impurities in liquid remaining in a container prior to filling may exceed the impurity limits of I.G.D. Product Specifications (Section 10, District Operations Manual), since the degree of such impurity will diminish in proportion to the liquid (liquid of high purity) being added during loading. Such condition will require a serious evaluation with regard to the end result (product-purity after loading), Prior to proceeding to load such container.

(c) The decision to proceed loading, or to purge the container prior to filling will be at the discretion of the District Manager of the facility. However, at no time will product which is below I.G.D. Product Purity Specification (Section 10, District Operations Manual) be loaded into containers for shipment except as permitted by Par. 5.2.1 of this specification.

4.6.1 Proceed to loading upon completion of the above, and upon compliance with the necessary safety considerations.

5. FILLING

5.1 Couple the container to be filled to the facility's cryogenic storage tank. Utilize the container's flash-vent and comply with standard purge and fill procedures applicable to the container being filled.

5.1.1 The facility operations personnel (operator) shall conduct a cursory visual inspection for condition of the fill-equipment each time a container is filled. Observance of any irregularities will necessitate a detailed examination of item(s) in question.

NOTE: Transfer hoses must be in good condition and remain

— dust-capped at all times except when in use. Fill-fittings and mating parts (unions) must be clean and free of deep nicks or scores. All oxygen, nitrogen, and argon transfer connections must remain dust-capped except when in use.

5.1.2 Certain APCI facilities are equipped with flash-vapor recovery systems. Such recovery systems can be utilized only when the container's residual liquid meets I.G.D. Product Purity Specification requirements. Certain other conditions also make usage of such recovery systems undesirable. Consequently, usage will be entirely dependent on policy of the facility and requires approval by the Facilities Operations Manager, "I.G.D."

5.2 The contents of the container must be sampled and analyzed again, after filling (See Sec. 6.3.1-3). The analysis results will be recorded on I.G.D. Form 3096 (Exhibit "B"), and also on I.G.D. Tag Form P-L No. 1 (Exhibit "A") representing the loaded container. The P-L Tag No. 1 will be filled-out in detail and attached to the container's product-drain valve (outlet, unloading, or discharge valve) in a secure manner.

5.2.1 Product purity must meet the requirements set forth by applicable I.G.D. Product Purity Specifications (Section 10 of the District Operations Manual) prior to its release for shipment to customers. The only exception to this policy will be intra-district shipments as defined by the following:

EXCEPTION: In some cases, shipments of product which do not meet I.G.D. Product Purity Specifications may be made to other APCI I.G.D. facilities for further purification.

6. LABELING

6.1 All bulk shipments will be labeled using I.G.D. Product Labeling Tag (P-L Tag No. 1) prior to releasing the container for shipment to customer. A facsimile of the P-L Tag No. 1 is depicted in Exhibit "A". The P-L Tag No. 1 provides spaces for recording the following pertinent data. It shall be filled-out in detail.

(a) Name of the facility where container was loaded

(b) Name of the product in the container

(c) Container description (tanker, trailer, railroad tanker, pumper, etc.) and identification number

*(d) Purity of the product in the container

*(e) Amounts of impurities, when required to meet particular

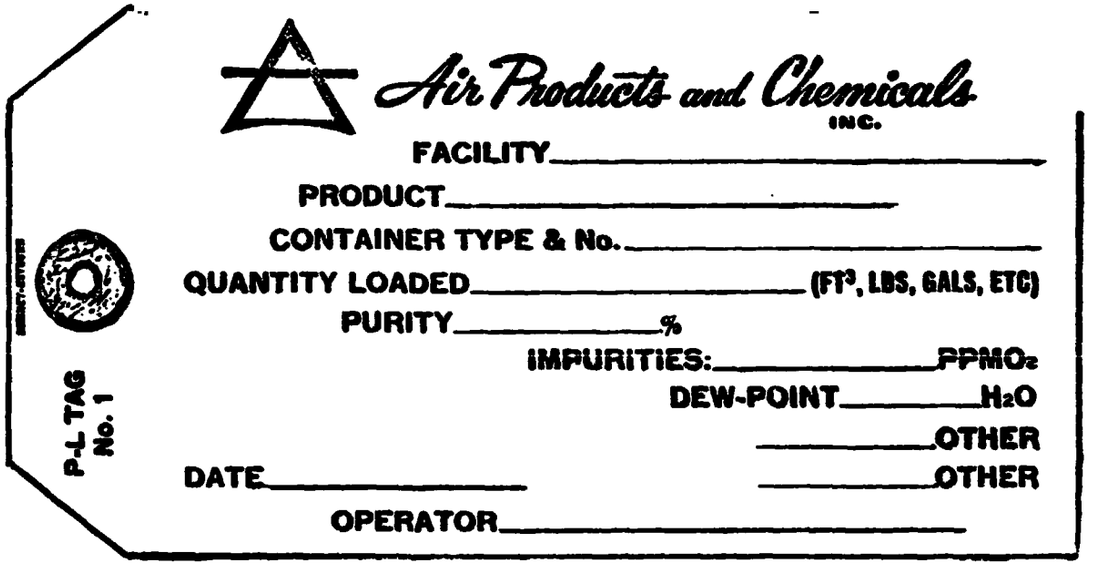
— customer specifications: e.g. dew point, ppm oxygen in nitrogen or argon, total hydrocarbons in oxygen

(f) Total quantity of product in the container, (may be omitted: not for billing purposes)

(g) Date and time container was filled; name (signature) of person who filled the container

*Purity and impurity analysis will be performed on the product in the bulk container, not on the product used in filling the container. Use cryogenic samplers if necessary.

EXHIBIT "A"



NOTE: This tag can be obtained from APCI Spare Parts Dept. at Allentown, Pa. by requesting APCI Stock Code Number 4-847-51-0020.

Air Products and Chemicals INC.

INDUSTRIAL GAS DIVISION

PRODUCTS ANALYSIS: Ultra high purity Argon, Puragon, Helium, High purity Hydrogen
Ultra high purity Hydrogen, High purity Nitrogen, Ultra high purity Nitrogen, Oxygen

Form 3096 Rev. 3
7-19-65 LCK

District_____ Month of_____

DATE	CYL, TANKER, OR TRAILER NUMBER	PRES. PSIG	GAS PURITY MOL %	OXYGEN PPM	DEW POINT °F	REMARKS

INDUSTRIAL & MEDICAL GAS DIVISION
DISTRICT OPERATIONS MANUAL
SECTION 9.1
EXHIBIT "B"

Form 3096-Rev. 3 - order directly from Stationery Stores, Allentown, Pa.

NOTE:

(a) This form will be used by districts in reporting the results of daily product analyses as required by the Filling Procedures described by Sections 3.2.1.1, 3.2.1.2, 3.2.1.3, 3.2.1.4, and 3.2.1.5 of the "I.G.D." District Operations Manual. Districts should use a separate form for each gas filled, and circle the gas analyzed. One (1) copy of the completed form should be retained by the district, and one (1) copy forwarded to the attention of the Chief Engineer, "I.G.D.", Allentown, Pennsylvania. The completed forms shall be transmitted on monthly basis during the first week of the month.

(b) Districts should also use this form to record shipment of quality control samples to the "I.G.D." Quality Control Laboratory, as required in Section 6.3 of the "I.G.D." District Operations Manual.

NOTES: All hoses are 10 ft. long.
All hose end connections are equipped with dust plug and chain assembly.
All male adapter assemblies are equipped with dust cap and chain assembly.
All above items stocked by Spare Parts Department under code numbers shown in parenthesis.

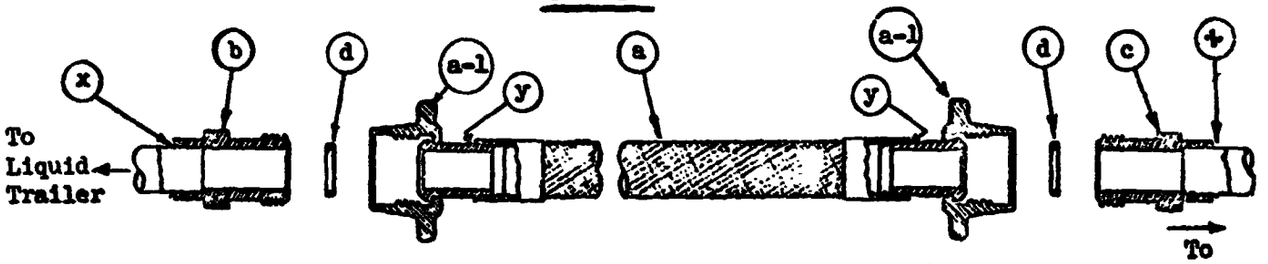
Part Nos. (a-1) and (a-2) hose union assemblies are actually sub-assemblies of complete hose assemblies (a). These union assemblies are also stocked by Spare Parts Department under code numbers shown.

Rev. 12/5/62 Rev. 11/19/63

EXHIBIT "C"

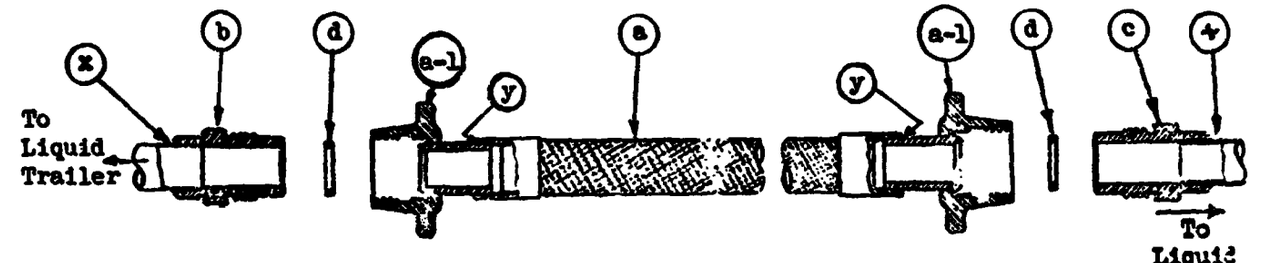
STANDARDS FOR LIQUEFIED GASES TRANSFER HOSES AND CONNECTIONS

OXYGEN



Size:	3"	1-1/2"	
Use:	Pressure Transfer	Pump Transfer	
Maximum Working Pressure:	50 PSIG	300 PSIG	
APCI Part Numbers:			
(a) Transfer Hose Assembly:	62917A (3-421-69-0002)	62916A (3-421-69-0003)	
(a-1) Hose Union Assembly:	62766C (5-916-17-0007)	62768C (5-916-17-0006)	
(b) Trailer Adapter Assembly:	62763C (5-916-17-0002)	62755C (5-916-17-0003)	
(c) Tank Adapter Assembly:	62763C (5-916-17-0002)	62755C (5-916-17-0003)	
(d) Gasket:	62744A (4-372-03-0028)	62751A (4-372-03-0029)	
Pipe Connections (x):	3-1/8" O.D. Female Sweat	1-5/8" O.D. Female Sweat	
(y):	3" NPT	1-1/2" NPT	

NITROGEN, ARGON, AND CRUDE ARGON



Size:	3"	1-1/2"	
Use:	Pressure Transfer	Pump Transfer	
Maximum Working Pressure:	50 PSIG	300 PSIG	
APCI Part Numbers:			
(a) Transfer Hose Assembly:	62918A (3-421-69-0004)	62935A (3-421-69-0005)	
(a-1) Hose Union Assembly:	62761C (5-916-17-0008)	62774C (5-916-17-0001)	
(b) Trailer Adapter Assembly:	62748C (5-916-17-0004)	62771C (5-916-17-0005)	
(c) Tank Adapter Assembly:	62748C (5-916-17-0004)	62771C (5-916-17-0005)	
(d) Gasket:	62744A (4-372-03-0028)	62751A (4-372-03-0029)	
Pipe Connections (x):	3-1/8" O.D. Female Sweat	1-5/8" O.D. Female Sweat	
(y):	3" NPT	1-1/2" NPT	

See notes on reverse side of page

PURGING METHODS

1. PURPOSE

This standard discusses the various purge methods and establishes a safety factor when the purge procedure involves a flammable gas.

2. SCOPE

This standard covers all applications and operations where it is necessary to remove contaminants from equipment systems and product storage containers prior to placing the system into service for the first time, opening it up to perform maintenance, or changing product service to prevent the formation of flammable-oxidant mixtures within the systems.

3. PURGE MEDIA

Nitrogen, readily available at most APCI locations, is the purge media applicable to this standard. The other inert gases, helium, argon, carbon dioxide, or any other material which will effectively eliminate the contaminant without introducing other problems or hazards to the system may also be used as purge media.

4. SAFETY FACTOR

In cases involving flammable gases, purging operations must continue until the remaining concentration is fifty percent (50%) of the lower flammability limit (LEL) of the flammable gas, fifty percent (50%) of the minimum allowable concentration of oxygen (MAC-O) needed for reaction when using nitrogen as a diluent, or fifty percent (50%) of the maximum allowable concentration of fuel gas (MAC-F) needed for reaction when using nitrogen as a diluent.

5. DATA

Figure No. 1, attached, is the flammability diagram of mixtures of methane, air, and nitrogen, and shows the quantitative composition relationships between the components. The explanation of Figure No. 1 is applicable to the flammability diagrams of the other flammable gases.

Table No. 1 lists the flammability limits and autoignition temperatures of some of the more common flammable gases. The table also lists the minimum concentration of oxygen needed for reaction and the maximum fuel gas needed for reaction when nitrogen is the inert gas used for purging. The above minimum oxygen and maximum fuel gas limits are not applicable if an inert gas other than nitrogen is used.

6. DEFINITIONS

A. Lower Flammability Limit, also known as Lower Explosive Limit (LEL) is the lowest volume percent of fuel gas mixed in air which is capable of being ignited.
Line BE on Figure No. 1

APCI DOCUMENT NO. 99002442

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PURGING METHODS

6. DEFINITIONS (Cont.)

B. Upper Flammability Limit, also known as Upper Explosive Limit (UEL) is the highest volume percent of fuel gas mixed in air which is capable of being ignited.
Line CE on Figure No. 1

C. Minimum Allowable Concentration of Oxygen (MAC-O) is the volume percent of oxygen below which a reaction with a fuel gas is impossible when using nitrogen as a diluent or purge gas in a system.
Point E on Figure No. 1

D. Maximum Allowable Concentration of Fuel Gas (MAC-F) is the volume percent of fuel gas with nitrogen as a diluent below which a reaction with oxygen is impossible.
Line EF on Figure No. 1

7. PURGING METHODS

Purging of a system or a vessel can be accomplished in several different ways.

A. Pressure Purge
B. Evacuation Purge
C. Combination of Pressure and Evacuation Purges
D. Flow-through Purge or Displacement Purge

The method selected may be determined by the design of the equipment (pressure and temperature), volume of equipment, availability of economic purge materials, compatibility of purge media with service of equipment, and the time available to perform the purge.

1.) Pressure Purge

Pressure purge is accomplished by diluting the normal product at one (1) atmosphere of pressure in a system with an inert gas such as nitrogen. The higher the purge pressure applied within the design of the system, the greater the dilution effect when the system is again reduced to one (1) atmosphere. The pressure purge may be repeated as many times as necessary to eliminate the hazard in flammable gas systems. A formula has been developed which becomes a useful tool in determining the purge pressure required to adequately purge a system to the desired level. This formula is listed below:

$$X = \sqrt[Y]{\frac{CI}{CF}}$$

where X = the purge pressure in atmospheres.
Y = the number of pressurization cycles.
CI = the concentration of contaminant at start of purge, volume percent.
CF = the required or final concentration of contaminant at end of purge, volume percent.

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PURGING METHODS

Example 1: To determine the pressure required to purge a methane tank of air prior to admitting methane. The purge gas is nitrogen. This condition is typical of placing a system into service for the first time or where it is returned to service after it has been opened for maintenance.

Known:
CI = 21%, the oxygen content of air.
CF = 6%, refer to Table No. 1 (Methane) under minimum percent oxygen and apply the 50% Safety Factor to 12.1%.
Y = Assume two (2) purge cycles.

$$X = \sqrt[Y]{\frac{CI}{CF}} = \sqrt[2]{\frac{21}{6}} = 1.87 \text{ atmospheres or } \underline{27.5 \text{ psi}}$$

NOTE: If the calculated purge pressure is less than the design pressure of the system, in this case, two (2) pressure purge cycles are adequate. If the calculated purge pressure is greater than the design pressure, it will be necessary to increase the number of purge cycles to reduce the purge pressure to a workable level.

Example 2: To determine the pressure required to purge a methane tank of methane prior to admitting air. The purge gas is nitrogen. This condition is typical of removing a system from flammable gas service prior to opening it for repairs or other purposes:

Known:
CI = 100%, the methane in the system.
CF = 7.1%, refer to Table No. 1 (Methane) under maximum percent fuel and apply the 50% Safety Factor to 14.2%
Y = Assume two (2) purge cycles.

$$X = \sqrt[Y]{\frac{CI}{CF}} = \sqrt[2]{\frac{100}{7.1}} = 3.76 \text{ atmospheres or } \underline{54.27 \text{ psi}}$$

NOTE: The gas being vented at the end of the first purge cycle is flammable, therefore releasing of this gas must be accomplished by venting out-of-doors, or through a stack venting out-of-doors, in an area free from ignition sources.

The gas being vented during the final purge cycle in the above two (2) examples and similar conditions must be monitored for oxygen and/or flammable gas content as applicable. An oxygen analyzer and an explosimeter are the instruments to use.

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PURGING METHODS

2.) Evacuation Purge

Evacuation purge procedure implies that the contaminant is withdrawn from the system by removing it with a vacuum pump and then diluting the residual gas by breaking the vacuum with an inert gas such as nitrogen. Evacuation purge is limited to systems which are designed with materials of construction to withstand the external forces on the system while under vacuum. Atmospheric storage tanks and liquid tanks generally cannot be subjected to an evacuation purge because of the danger of collapse.

A single evacuation of a system is capable of reducing the concentration of the contaminant to a level of about 7.6% of the system volume. If the contaminant being removed is air, the residual oxygen is about 1.6%. This level of oxygen contamination is well below where it would become a problem with most flammable gases.

Additional evacuation cycles, including a breaking of the vacuum with an inert gas, may be used to further reduce the contamination level.

3.) Combination of Pressure and Evacuation Purges

This method of purging combines the pressure and evacuation purge methods. The combined methods may allow completion of a purge operation more quickly.

4.) Flow-through or Displacement Purge

An inert purge gas, and in some applications a liquid flowing through a vented system will displace any contaminant gas from the system. Uncomplicated systems, such as transfer lines, can be effectively purged using a flow-through technique. All connecting piping, dead legs, etc., must be blown out individually. "Plug" flow, rather than turbulent flow is recommended. The discharge from a system must be monitored by analyzers or other instrumentation to make certain the contaminant has been displaced to a level below which it no longer is a problem.

8. MONITORING INSTRUMENTS

It is recommended that purging operations be monitored, particularly when the equipment being purged is large, the system is complicated, and as a check upon the adequacy of the purging procedure.

An explosimeter should be used to detect the presence of residual amounts of flammable gases when the equipment being purged has contained flammable gases.

A false reading will be obtained on an explosimeter when air is not added to the sample of nitrogen-fuel purge gas. It is necessary that a dilution or mixing valve be part of the explosimeter in order to obtain meaningful analysis

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PURGING METHODS

8. MONITORING INSTRUMENTS (Cont.)

with the instrument.

An oxygen analyzer should be used to detect the presence of oxygen within the equipment prior to admitting flammable gases.

9. HAZARDS

Several hazards must be considered during purge operations with all purge methods. When the purge gas used is an inert gas, the hazard of asphyxiation is present. Adequate ventilation is required to reduce the hazard. Large volumes of inert purge gas must be vented out-of-doors.

A fire and explosion hazard exists whenever equipment to be purged contains flammable gases. Venting of these systems must be out-of-doors in areas away from sources of ignition.

10. REFERENCES

Bulletin 627, Bureau of Mines, Flammability Characteristics of Combustible Gases and Vapors, Zabetakis, M.G.

Bulletin 503, Bureau of Mines, Limits of Flammability of Gases and Vapors, Coward, H. F. and Jones, G. W.

Air Products and Chemicals, Inc., Technical Data Book.

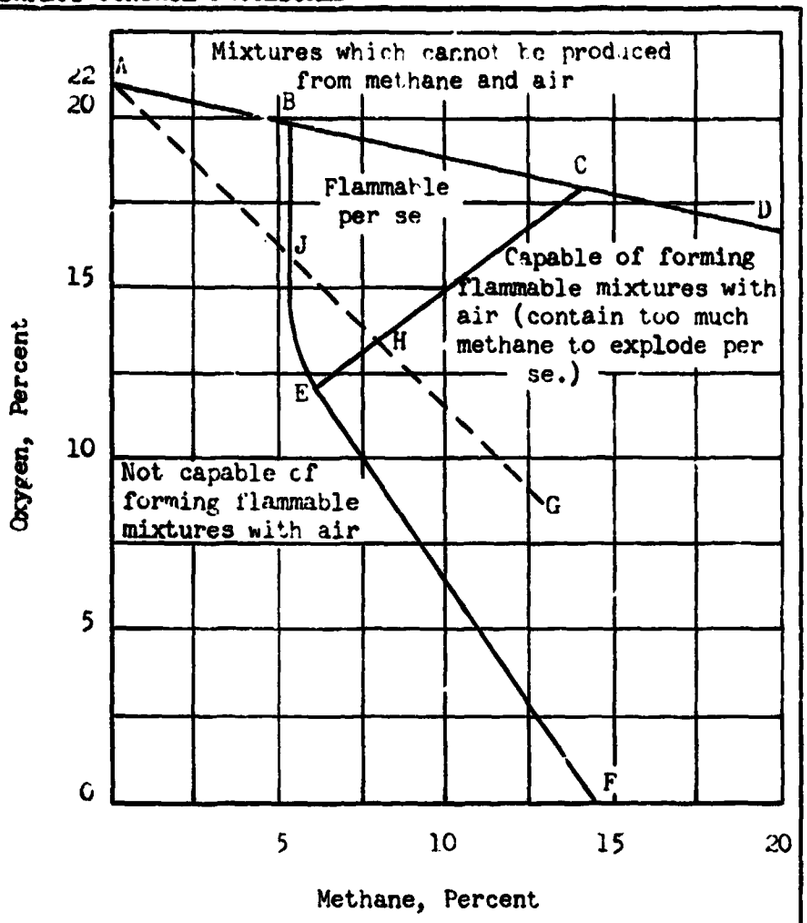
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SAFETY STANDARDS

626 SAFETY CONTROL PROCEDURES

RELATION BETWEEN
QUANTITATIVE COMPOSITION
AND
FLAMMABILITY OF MIXTURES
OF
METHANE, AIR,
AND NITROGEN

Figure No. 1



The straight line AD represents the composition of all mixtures of methane and pure air that contain up to 20% methane. No mixture of methane and air can fall above this line, and all mixtures of methane, air and nitrogen must fall below it. The line BE is the line of lower limits of flammability of methane, and CE the line of higher limits. As the oxygen content falls, BE and CE approach each other until they meet at E. No mixture which contains less oxygen than that corresponding with E is explosive per se, but all mixtures in the area BEC are within the limits of flammability and are therefore explosive.

Next, consider any mixture to the right of line CEF; e.g. the mixture represented by G. Join GA, then GA represents the mixtures formed, in succession, as G is diluted with air. Because GA passes through the area BEC, the mixture, as it is diluted with air, becomes explosive and remains so as long as its composition is represented by any point on HJ.

It will now be clear that the position of FE is exactly defined by drawing a tangent from A to the curve BEC and extending the tangent to meet the axis of abscissas in F, because the line joining any point above and to the right of FE to A must pass through BEC, while the line joining any point below and to the left of FE to A must fail to pass through the explosive region BEC. FE is therefore the boundary of those mixtures capable of forming explosive mixtures with air.

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Date
Jan. 1970

TABLE NO. 1

FLAMMABILITY LIMITS OF GASES

IN AIR AT 70°F. AND ATMOSPHERIC PRESSURE

NAME	FORMULA	VOLUME %		PERCENT NEEDED FOR REACTION WITH NITROGEN AS THE INERT		AUTOIGNITION TEMPERATURE °F.
		LOWER	UPPER	MINIMUM OXYGEN	MAXIMUM FUEL	
Acetylene	C_2H_2	2.5	81.0	-	-	580
Ammonia	NH_3	15.0	28.0	-	-	1204
Butadiene, 1, 3-	C_4H_6	2.0	11.5	10.4	4.9	788
Butane, iso	C_4H_{10}	1.80	8.4	12.0	6.2	864
Butane, normal	C_4H_{10}	1.8	8.4	12.1	6.3	764
Butene, 1-	C_4H_8	1.6	10.0	11.6	3.5	728
Butene, 2-	C_4H_8	1.7	9.70	-	-	620
Carbon Monoxide	CO	12.5	74.2	5.6	20.0	1128
Carbonyl Sulfide	COS	11.9	29.0	-	-	-
Cyanogen	C_2N_2	6.0	42.6	-	-	-
Cyclopropane	C_3H_6	2.4	10.4	11.7	5.4	932
Ethane	C_2H_6	3.0	12.4	11.0	7.8	960
Ethylene	C_2H_4	2.7	32.0	10.0	5.5	914
Ethylene Oxide	C_2H_4O	3.0	100.0	-	-	804
Hydrogen	H_2	4.0	75.0	5.0	5.0	752
Hydrogen Sulfide	H_2S	4.0	44.0	-	-	500
Methane	CH_4	5.0	15.0	12.1	14.2	1004
Methylamine, Mono-	CH_3NH_2	4.9	20.7	-	-	806
Methylamine, Di-	$(CH_3)_2NH$	2.8	14.4	-	-	806
Methylamine, Tri-	$(CH_3)_3N$	2.0	11.6	-	-	374
Methyl Chloride	CH_3Cl	10.7	17.4	-	-	1170
Methyl Ethyl Ether	$CH_3OC_2H_5$	2.0	10.0	-	-	374
Pentane, Neo	C_5H_{12}	1.4	7.8	12.1	5.7	500
Propane	C_3H_8	2.2	9.5	11.4	6.6	842
Propylene	C_3H_6	2.4	11.10	11.5	5.4	860
Vinyl Chloride	C_2H_3Cl	3.6	33.0	-	-	882

Air Products and Chemicals

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Date
Feb. 1970

INDUSTRIAL SAFETY POLICY

1. PURPOSE

This safety standard defines the supervisory responsibility for safety throughout the company.

2. SCOPE

This safety standard encompasses all levels of supervision and it is to be used as a guide in the daily responsibility for safety.

3. OBJECTIVE

Air Products' concept is not production and safety as exemplified by the well known idiom of "Safety First ; rather it is production with safety in the sense that safety is a production tool. When production with safety is achieved, production with efficiency is attained simultaneously.

Although Senior Management has major responsibility for establishing definite safety policies, procedures, and safe working conditions, most of what is planned and established must reach the employee on the job by way of the First-Line Supervisor who is in frequent and close association with employees.

Safety as a line function must be accepted by every supervisor as a part of his assigned responsibility and by every employee as a production tool.

4. ORGANIZATION

Senior Management shall be responsible for the inception and effectiveness of the safety program throughout the company.

The Safety Department shall be responsible for the establishment of corporate safety policy and programs and for periodic review of the safety program at each facility.

The Department Manager shall be accountable to Senior Management for all accidents resulting from activities within his control and shall be responsible for the effective operation of the safety program within his department.

The Region or Section Manager shall be accountable to the Department Manager for all accidents resulting from activities within his jurisdiction and shall further be responsible for the effectiveness of the safety program within his region (or section).

The Plant or District Manager shall be accountable to the Region or Section Manager for all accidents resulting from activities within his control He shall further be responsible for the effectiveness of the safety program within his plant or district.

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APCI DOCUMENT NO. 92000241

INDUSTRIAL SAFETY POLICY

4. ORGANIZATION (Contd)

The First Line Supervisor (Foreman, Shift Supervisor, etc.) shall be accountable to the Plant or District Manager for all accidents resulting from activities under his supervision. He shall be responsible for the effectiveness of the safety program in connection with all operations in which he may become involved.

From time to time it is necessary to set up special groups or task forces to handle particular problems; for example, special engineering projects or construction activities. In these instances, the supervisors at the various levels of the group shall operate under the basic philosophy that safety is a line function. They shall be accountable for all accidents resulting from activities within their jurisdiction and shall be responsible for the effectiveness of the safety program within their realm of responsibility.

5. GENERAL RESPONSIBILITIES

A. Senior Management

Senior Management shall be responsible for the inception and effectiveness of the corporate safety program. They shall:

(1) Provide the direction, incentive, and motivation to insure a dynamic safety program throughout the company.

(2) Delegate to each Department Manager the authority to provide safe equipment and a safe working environment in their specific areas.

(3) Consult with the Safety Department in the interest of constantly affecting improvement in the operation of the safety program.

(4) Review reports and analyses from the Safety Department for the purpose of evaluation of the safety program.

B. Safety Department

The Safety Department will have a staff relationship to every department of the company concerning all safety matters. The Safety Department shall:

(1) Formulate corporate safe policy and the overall safety program.

(2) Perform periodic safety inspections at all company facilities, report on conditions observed and recommend remedial action where necessary.

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INDUSTRIAL SAFETY POLICY

5. GENERAL RESPONSIBILITIES (Contd)

B. Safety Department

(3) Procure and disseminate safety information to all departments of the company.

(4) Review and analyze safety reports from the various facilities and make such recommendations as are necessary.

(5) Compile statistics with regard to the frequency, severity, and causes of accidents and recommend corrective action to management.

(6) Be available to all departments for consultation on any and all safety problems.

C. Department Managers

The Department Manager shall be responsible to Senior Management for the prevention of accidents and the effectiveness of the safety program within his department. He shall:

(1) Delegate authority for the control of accidents to the various supervisors reporting to him.

(2) Amplify and clarify procedures as necessary to insure compliance within his area.

(3) Consult with the Safety Department in the interest of constantly affecting improvement in the operation of the safety program.

(4) Review reports and analyses from the Safety Department for the purpose of evaluation of his safety program.

D. Region or Section Managers

The Region or Section Manager shall be responsible to the Department Manager for accidents and for the effectiveness of the safety program within his region or section. He shall:

(1) Delegate authority for the control of accidents to each District or Plant Manager.

(2) Delegate to the Safety Engineer or Supervisor (if such a position is included in his organization) such authority as is required to insure an effective and dynamic safety program within his region or district.

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INDUSTRIAL SAFETY POLICY

5. GENERAL RESPONSIBILITIES (Contd)

D. Region or Section Managers

(3) Consult with the Safety Department in the interest of constantly affecting improvement in the operation of the safety program.

(4) Review all aspects of safety with the Safety Department and each District or Plant Manager.

(5) Review the monthly summary of injury form (Form 2021) with each District or Plant Manager.

E. Plant or District Manager

The Plant or District Manager shall be responsible for the prevention of accidents and for the effectiveness of the safety program within his plant or district. He shall:

(1) Delegate authority for the control of accidents to the various supervisors and foremen reporting to him.

(2) Delegate to the Safety Supervisor (if such a position is included in his organization) such authority as is required to insure an effective and dynamic safety program within his plant or district.

(3) Delegate authority to the various foremen for the administration of the safety program within the scope of their operations.

(4) Hold not less than one safety meeting a month at all locations where manufacturing and operations activities are performed. Representatives of both hourly and supervisory employees shall be included on a rotating basis.

(5) Investigate all accidents with the supervisor involved.

(6) Consult with the First Line Supervisors on individual and joint problems relating to the safety program.

(7) Keep equipment in top operating condition and set up and maintain a satisfactory housekeeping program.

(8) Maintain the following accident records as received from the First Line Supervisor:

a. First Aid Report (Form 2019).

b. First Report of Accident (Form LC-2680; Florida only, Form LC-3621).

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5. GENERAL RESPONSIBILITIES (Contd)

E. Plant or District Manager

(8) Maintain the following accident records as received from the First Line Supervisor: (Contd)

c. Supervisor's Accident Investigation Report (Form 2020)

d. Near Accidents, Unsafe Practices or Conditions (Form 2023)

(9) Prepare and submit the following report:

a. Monthly Summary of Injuries (Form 2021)

Original - Safety Department
One Copy - Facility Files

F. First Line Supervisors (Foremen, Shift Supervisors, etc.)

Each First Line Supervisor shall be responsible to the Plant Manager for the prevention of accidents to employees and equipment under his supervision, and shall incorporate the following into his principal duties:

(1) Teach employees that accidents are caused and they can be prevented.

(2) Teach each employee what the hazards are on his job and how to avoid them.

(3) Impart to each employee the understanding that the violation of established safety rules will not be tolerated.

(4) See that needed safety equipment and protective devices are provided for each job.

(5) Take prompt corrective action whenever unsafe conditions and unsafe acts are noted.

(6) Instill a safety awareness in each employee through personal safety contacts.

(7) Conduct safety appraisals of his section. This includes a careful check of all new and relocated equipment before placed in operation.

(8) Give full support to all safety activities and safety procedures.

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INDUSTRIAL SAFETY POLICY

5. GENERAL RESPONSIBILITIES (Contd)

F. First Line Supervisors (Foremen, Shift Supervisors, etc.)

(9) Investigate and find the cause of all accidents, even those which result in minor injuries.

(10) See that all injuries are reported and properly treated.

(11) Prepare and submit the following reports as required:

a. First Aid Form (Form 2019)

This form is to be filled out for each accident requiring first aid. One copy is to be maintained at the facility and one copy to be sent to the Safety Department.

b. The First Report of Accident (Form LC-2680; Florida only, Form LC-3621)

This form is to be filled out for any injury requiring medical attention over and above first aid. One copy retained in the facility file, one copy to the local Hartford Insurance Co. office, one copy to the Treasurer's Office, one copy to the Personnel Department, one copy to the Safety Department and one copy to the state, if needed.

c. Supervisor Accident Investigation Report (Form 2020)

This form shall be filled out for every injury involving lost time or any accident or injury no matter how slight which involves unusual circumstances. One copy to be retained at the facility and one copy to the Safety Department.

d. Near Accidents, Unsafe Practices or Conditions (Form 2023)

This form is to be filled out on an accident no matter how slight which might have been of a serious nature, or for an unsafe practice or condition. One copy retained at the facility and one copy sent to the Safety Department.

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INDUSTRIAL SAFETY POLICY

5. GENERAL RESPONSIBILITIES (Contd)

G. Executive Safety Council

(1) The Executive Safety Council will be comprised of the following personnel:

a. Senior Management Member (Chairman)

b. Safety Director

c. Personnel Director

d. Four representatives of major departments or divisions

(2) The Executive Safety Council shall:

a. Meet each quarter.

b. Discuss and determine action to be taken on accident control problems that are indicated by the Safety Director's analyses and reports. Prepare directives for the President which are to be issued to plant supervisory personnel indicating specific measures necessary to improve the safety program.

c. Submit a statement to the President after each meeting of the progress of the safety program.

d. The Senior Management member, Safety Director and Personnel Director shall be permanent members of the council. Other members shall be rotated, one new member to be named each quarter.

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6 FORMS

A. Index

TITLE	FORM NO.
(1) First Aid Report	2019
(2) Monthly Summary of Injuries	2021
(3) Supervisor Accident Investigation Report	2020
(4) Near Accidents, Unsafe Practices or Conditions	2023

B. Availability

The above forms are available at APCI Stationery Stores, Trexlertown, Pennsylvania. Order the standard forms by specifying the appropriate form number listed above.

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FORM NO. 2019

Case No._____ Date_____

First Aid Report

Name_____ Clock No._____ Department Plant_____

Male ☐ Female ☐ Occupation_____ Foreman_____

Date of Injury_____ Time___ a.m. p.m. Date of First Treatment_____ Time___ a.m. p.m.

Nature of Injury_____

_____

Sent: Back to Work ☐ Doctor ☐ Home ☐ Hospital ☐

Estimated Disability_____days. Name of Witness_____

Injured's Description of Accident_____

_____

_____

Signed_____
First Aid Man or Nurse

Air Products, Inc.

Form 2019

(Use reverse side for additional information)

Air Products ...INCORPORATED	Originated By: W. L. BALL	Approved: Safety Director W. L. BALL	Date 10-3-61

All information hereon is the confidential property of Air Products, Inc., unless another source is shown, on demand and must not be disclosed or reproduced without prior written consent.

FORM NO. 2021

Monthly Summary of Injuries

DATE _____

TO W. L. Ball - Safety Dept.

SUBJECT: Monthly Summary of Injuries

FROM _____

for the Month of _____

LOCATION _____

	Summary	No. This Month
1.	First-Aid Cases	
2.	Doctors Cases	
3.	Lost Time Cases	
4.	No. of Days Lost	
5.	Near Misses	
6.	Avg. No. of Employees	
7.	Man Hours Worked	

COMMENTS:

NOTE:

1. First-Aid Cases - Any injury requiring local first-aid supplies.
2. Doctor Cases - Any injury requiring medical attention other than local first-aid supplies.
3. Lost Time Cases - All injuries involving time lost from the job.
4. No. of Days Lost - Total of all days lost from the job due to industrial causes.
5. Near Misses - Occurrences which might have caused extensive injury or damage.
6. Avg. No. of Employees - Include all employees (administration, etc.).
7. Man Hours Worked - Total hours worked, if available; if not, take the average number of employees and multiply by eight hours. Take this figure and multiply by the number of days worked.

Form No. 2021

Air Products ...INCORPORATED	Originated By: W. L. BALL	Approved: Safety Director W. L. BALL	Date 10-3-61

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FORM NO. 2020

Air Products and Chemicals inc.

Office Use

Non-Disabling [ ]

Supervisor Accident Investigation Report Disabling (lost-time) [ ]

Name of Injured _____ Clock No. _____ Date of Injury _____

Age _____ Length of Service: With Company _____ on Present Job _____

Occupation _____

Nature of Injury _____

Description of Accident

(This information is for use in preventing similar accidents. Answer questions specifically, as indicated by example.)

1. What Job Was Employee Doing Including Tools, Machine and Materials Used? (Example: *Lifting a heavy casting onto a four wheel truck.*)

_____

_____

2. How Was Employee Injured? (Example: The casting *slipped* from his *grasp* and *fell* on his toes.)

_____

_____

_____

3. What Did Employee Do Unsafely? (Example: Tried to lift *too heavy load.*)

_____

_____

4. What Was Defective, In Unsafe Condition, or Wrong with Method? (Example: Should have had *help.*)

_____

_____

5. What Safeguards Should Be Used? (Example: Wear *Safety Shoes.*)

_____

_____

6. What Steps Were Taken to Prevent Similar Injuries? (Example: Instructed men to assist each other in lifting heavy loads.)

_____

_____

7. What Other Steps Should Be Taken to Prevent a Recurrence? (Example: Provide mechanical handling equipment for this work.)

_____

_____

_____

Signed _____

Department _____

Plant _____

(Over)

Form 2020

Air Products ...INCORPORATED	Originated By: W. L. BALL	Approved: Safety Director W. L. BALL	Date 10-3-61

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FORM NO. 2020
(Reverse Side)

For Office Use Only

(Enter as Facts become available)

8. Temporary Total ☐ Permanent Partial ☐ Death or Permanent Total ☐

Started losing time_____ Part of Body_____ Time charge_____

Returned to work _____ Per cent loss or loss of use_____

Time charge _____ Time charge_____ _____

9. Compensation $_____ Medical $_____ Other $_____

Air Products ...INCORPORATED	Originated By: W. L. BALL	Approved: Safety Director W. L. BALL	Date 10-3-61

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FORM NO. 2023

Air Products and Chemicals INC.

NEAR ACCIDENTS
UNSAFE PRACTICES OR CONDITIONS

DATE _____

*COPY TO: Safety Department - Trexlertown

PLANT _____ DEPARTMENT _____

PERSON SUBMITTING REPORT _____

WHERE THE ACCIDENT OR UNSAFE PRACTICE OCCURRED _____

DESCRIPTION OF THE EVENT OR CONDITION _____

SUGGESTION FOR CORRECTION _____

ACTION TAKEN FOR CORRECTION _____

*Copies should be directed to the Safety Department and also to the manager of the department originating the report.

Form 2023

Air Products ...INCORPORATED	Originated By: W. L. BALL	Approved: Safety Director W. L. BALL	Date 10-3-61

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Air Products and Chemicals INC.

STANDARD FOR THE INSTALLATION AND OPERATION OF OXYGEN-FUEL GAS SYSTEMS FOR WELDING AND CUTTING

by

National Fire Prevention Association

1962

NFPA-No-518 32P

APCI DOCUMENT NO 990002342

APCI DESIGN ENGINEERING STANDARD 534.1

OXYGEN CONTROL PANEL

(to be published)

APCI DOCUMENT
NO. 9800002343

OUTSIDE FIRE HYDRANT

1. PURPOSE

This standard establishes approved fire hydrants for outside use.

2. SCOPE

This standard applies to all facilities designed by API.

3. GENERAL

The following approved and standardized outside fire hydrants are required on all facilities revised or constructed following the date of this standard. This standard governs unless supplimented or superseded by the "Recommended Safety Equipment List" prepared by API Safety Department for each installation.

4. EQUIPMENT

A. Hydrant

(1) Specification

a. Hydrants to be a "Darling" B-550B (or equal) with a five (5) inch barrel and a six (6) inch base or a base to agree with fitting of the header. A standard pumper hose nozzle and two (2) 2 1/2" outside independent fire hose nozzles set 90° to the barrel will be included. The length of the hydrant to agree with the depth of the trench (set below the freeze line). Eight (8) cubic feet of 3/4 inch crushed rock will be used to afford hydrant drainage.

b. Hydrant painting will be as follows:

/1/ Barrel - Fire protection red, Sacony 33-R-104

/2/ Cape - Diffuse aluminum, Sacony 11-A-30.

c. Secondary gate valves for hydrants are necessary only where there is a possibility of damage from vehicle traffic.

(2) Vendor

Darling Valve and Manufacturing Company, Williamsport, Pa. or equal.

Air Products ...INCORPORATED	Originated By: H. SMITH	Approved: Safety Director L. BALL	Date 7-26-61

APCI DOCUMENT NO. 99000244

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OUTSIDE

HYDRANT HOUSE AND EQUIPMENT

1. PURPOSE

This standard establishes the criteria for the selection of approved fire protection equipment for outside use.

2. SCOPE

This standard applies to all APCI facilities.

3. GENERAL

The following approved hydrant house and related support equipment is required on all facilities revised or constructed following the date of this standard. This standard governs, unless supplemented or superseded by the "Recommended Safety Equipment List" prepared by the APCI Safety Department for each installation. Any change to this Standard requires approval by the Safety Department.

4. EQUIPMENT

A. Hydrant House

(1) Specification

a. Hydrant house will be fabricated of rolled 20 gauge cold steel on structural steel frame and base. The door will be side opening, swing type, with a snap hasp.

b. The house will be shop primed by the manufacturer, and finished painted in the field a fire department red with six (6) inch white lettering and numbering (Hose House No. 1, etc.)

c. The recommended house is a SECO-H-1.

(2) Vendor

George W. Kistler, Inc.
122 Turner Street
Allentown, Pa.

B. Fire Hose

(1) Specification

a. All fire hose (1-1/2" or 2-1/2") will be dacron Super Flex-Fold. The hose tube is neoprene, and the jacket 100 per cent dacron yarn. Hose sections will be fifty (50) foot sections with a standard U.L. test pressure of three hundred (300) pounds. Couplings will be of brass both male and female: the female is to be a swivel joint. Lugs to be of the rocker type only.

Air Products and Chemicals

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Date
Revised
June 15, 1970

APCI DOCUMENT NO. 99000245

OUTSIDE HYDRANT HOUSE AND EQUIPMENT

4. EQUIPMENT

B. Fire Hose

(1) Specification (Cont.)

b. All threads to agree with the local fire department servicing the facility. Where there is no fire department service, the threads are to be national standard.

(2) Vendor

George W. Kistler, Inc.
122 Turner Street
Allentown, Pa.

C. Nozzles and Fittings

(1) Specifications

All nozzles will be of brass. Standard nozzles used are as follows:

a. 2-1/2" combination fog and straight stream - Akron 1725 Turbojet.

b. 1-1/2" combination fog and straight stream - Akron 1214.

c. 2-1/2" x 24" underwriter's play pipe with an underwriter's play pipe tip - style 540 straight tip.

(2) Hydrant gate valve and leader line wye will be of brass and have rocker lugs.

a. 2-1/2" gate valve - Akron 285.
b. 2-1/2" female x 1-1/2" x 1-1/2" male wye - Akron Pyrolite 1581.

(3) Spanner wrenches will be of the universal type and be cadmium plated malleable iron - Akron style 10.

(4) Hydrant wrench will be cadmium plated malleable iron - Akron style 17.

(5) Utility bar will be cadmium plated malleable iron - Akron style 50.

(6) Vendor

George W. Kistler, Inc.
122 Turner Street
Allentown, Pa.

Air Products and Chemicals

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Date
Revised
June 15, 1970

OUTSIDE HYDRANT HOUSE AND EQUIPMENT

5. EQUIPMENT SUMMARY FOR EACH HYDRANT HOUSE, UNLESS OTHERWISE STATED IN THE "RECOMMENDED SAFETY EQUIPMENT LIST."

A. one (1) hydrant house

B. four (4) spanner wrenches

C. one (1) hydrant wrench

D. one (1) 2-1/2" gate valve

E. one (1) 2-1/2" x 1-1/2" x 1-1/2" reduction wye, with ball shutoff valves.

F. one (1) utility bar.

G. one (1) 2-1/2" combination fog and straight stream nozzle.

H. two (2) 1-1/2" combination fog and straight stream nozzles.

I. two (2) 50-foot lengths of 2-1/2" hose (100 ft. total)

J. four (4) 50-foot lengths of 1-1/2" hose (200 ft. total)

6. SPECIAL NOTES

A. Only one underwriter's play pipe is required for each facility.

B. Only the above stipulated items will be stored in any hydrant house.

C. Spare parts to be stocked at each facility are as follows:

(1) two (2) spanner wrenches

(2) one (1) hydrant wrench

D. Vendor is listed in sections 4 and 5 of this Standard.

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INSIDE - OUTSIDE

1. PURPOSE

This standard establishes approved fire extinguishers for use on Class A, B, and C fires.

2. SCOPE

This standard applies to all APCI facilities. For facilities already equipped with fire extinguishers, this standard shall apply to all repalcement equipment.

3. GENERAL

The following approved and standardized fire extinguishment equipment is required on all facilities revised, or constructed following the date of this standard. This standard governs unless supplemented or superseded by the "Recommended Safety Equipment List" prepared by the APCI Safety Department for each installation. Any changes to this standard require approval by the Safety Department.

4. CLASS "A" FIRES (WOOD, CLOTH, PAPER, RUBBISH, ETC.)

A. TYPES

(1) Pressurized water extinguisher, 2 1/2 gallon, Underwriters' rating 2-A calcium chloride required in freezing weather.

(2) Foam extinguisher, 2 1/2 gallon, Underwriters' rating 2-A, subject to freezing.

B. VENDORS

Pressurized water - the Ansul Company, 215 Plank Avenue, Paoli, Pennsylvania 19301 or equal.

Foam - Fyr-Fyter Company, Philadelphia, Pennsylvania, or equal.

5. CLASS "B" FIRES (OIL, GASOLINE, GREASE, PAINT, ETC.)

A. TYPES

(1) Dry chemical (Foray all purpose) extinguishers of 10, 20, 30, 150, and 350 pound capacity. Underwriters' ratings of 2-A:30-B:C, 4-A:40-B:C, 6-A:60-B:C, 20-A:160-B:C, and 40-A:240-B:C respectively. Dry powder is not subject to freezing.

(2) Carbon dioxide extinguishers of 5, 10, 15, 20, 50, 75, and 100 pound capacity. Underwriters' ratings of 4-B, 8-B, 10-B, 12-B, 16-B, 20-B, and 40-B respectively. Carbon dioxide is not subject to freezing.

(3) Foam extinguishers of 2 1/2, 5, 17, and 33 gallon capacity. Underwriters' ratings of 6-B, 6B, 12-B and 40-B respectively. Foam is subject to freezing.

Air Products and Chemicals

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Date May, 1968

APCI DOCUMENT NO. 99000246

b. VENDORS

Dry chemical - The Ansul Company, 215 Plank Avenue, Paoli, Pennsylvania 19301, or equal.

Carbon dioxide - The Ansul Company, 215 Plank Avenue, Paoli, Pennsylvania 19301, or equal.

Foam - Fyr-Fyter Company, 6806 North Franklin Street, Philadelphia, Pennsylvania 19133, or equal.

NOTE #1 - Safety-first fire extinguishers may be substituted for the Ansul units in areas where repair and servicing is available at APCI IGD Southern Area Facilities. Safety-first extinguishers are available from the APCI Bladensburg Facility.

6. CLASS "C" FIRES (ELECTRICAL EQUIPMENT)

A. TYPES

(1) Dry chemical (Foray all purpose) extinguishers of 10, 20, 30, 150, and 350 pound capacity. Underwriters' ratings of 2-A:30-B:C, 4-A:40-B:C, 6-A:60-B:C, 20-A:160-B:C, and 40-A:240-B:C respectively. Dry powder is not subject to freezing.

(2) Carbon dioxide extinguishers of 5, 10, 15, 20, 50, 75, and 100 pound capacity. Underwriters ratings of 4-C, 8-C, 10-C, 12-C, 20-C, and 40-C respectively. Carbon dioxide is not subject to freezing.

B. VENDORS

Dry chemical - The Ansul Company, 215 Plank Avenue, Paoli, Pennsylvania 19301.

Carbon Dioxide - The Ansul Company, 215 Plank Avenue, Paoli, Pennsylvania 19301.

7. SPECIAL USE EXTINGUISHERS

For certain projects or facilities, specific special use extinguishers are required. The Safety Department shall be contacted for the selection of any special use extinguishers.

8. LIST OF EXTINGUISHERS IN USE BY APCI

The following is a list of fire extinguishers currently being utilized by APCI facilities.

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INSIDE - OUTSIDE

7. LIST OF EXTINGUISHERS IN USE BY APCI (Cont)

Type	Class of Use	Capacity	Vendor	Model No.
Pressurized Water	A	2 1/2 gal.	Ansul	W-2 1/2
Foam	A-B	2 1/2 gal.	Fyr-Fyter	FW-12
Carbon Dioxide	B-C	5 lbs.	Ansul	CD-5
Carbon Dioxide	B-C	10 lbs.	Ansul	CD-10
Carbon Dioxide	B-C	15 lbs.	Ansul	CD-15
Dry Chemical	A-B-C	10 lbs.	Ansul	A-10-E
Dry Chemical	A-B-C	20 lbs.	Ansul	A-20-E
Dry Chemical	A-B-C	30 lbs.	Ansul	A-30-E
Dry Chemical	A-B-C	150 lbs.	Ansul	A-150-E
Dry Chemical	A-B-C	150 lbs.	Ansul (rubber tires)	RT-A-150-C
Dry Chemical	A-B-C	350 lbs.	Ansul	A-350-C
Dry Chemical	A-B-C	350 lbs.	Ansul (rubber tires)	RT-A-350-C

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AIR PRODUCTS AND CHEMICALS, INC.

DRAWING 92483 D, REVISION B

LOX & LIN VAPOR DISPOSAL TANK (500 GALLON)
SEPTEMBER 30, 1968

DOCUMENT NOT AVAILABLE FOR GENERAL DISTRIBUTION

APCI DOCUMENT
NO. 9000247

Air Products and Chemicals

PUT IT IN WRITING

Date March 22, 1971

To W. J. Scharle Subject Lathrop Auto-Load System

From H. H. Master

( ) Take Action ( ) For Your Approval ( ) For Your Info ( ) Discuss With Me

( ) For Your Comments ( ) As Requested ( ) File ( ) Note & Return

cc: W. L. Ball
J. P. Desnouee
M. H. Halsted
F. K. Kitson
A. W. Norman
B. Trammell
H. E. Wynn

Attached is a diagram of the Lathrop auto-load system with a description of the operation and some details on the components, original and added, to accomplish the purpose. One change will be made to comply with the attached and another must still be added. The change will be to install the pressure switch downstream of the solenoid valve to actuate the red light in the control room. The present system turns on the light with the solenoid electrical circuit and it is possible that the solenoid valve may not have closed (it did hang up once due to burr on valve) mechanically even though the power to the circuit has been disrupted. With the pressure switch arrangement there will be a positive indication of pressure to the valve actuator. The addition recommended by the writer is the pressure level switch on the vapor dispersal tank. In the event anyone of the individual loading systems would fail the liquid into the dispersal system tank would actuate this switch sounding an alarm to warn the operator to get to the area and repair the malfunction or shut off manually.

Barton gauge switches are set for 58" to fill tankers. Other type trailers or locations may have some differences and will have to set accordingly. Also, setting must be made to have tractor disconnected or attached. With a level switch set for the tractor attached it will overload with it detached.

If the dispersal tank is to be used for dumping off-spec liquid or for purging in conversion operations, it will be necessary to bypass the vapor dispersal tank level-alarm switch. In the event this is done (rarely at this location) the operator shall stay in the area. On such occasions there will be more reason to stay in the area to accomplish the purge.

To avoid malfunction or false alarms with the vapor dispersal tank level switch the following piping configuration is suggested. Drill a 1/2" hole in the tank as low as possible on its side and weld a half coupling over the hole. Coupling shall pitch slightly upward to permit any condensation to drain. Install a 1/2" x 5" long stainless steel pipe nipple into the coupling. Then install a stainless or brass elbow on the nipple heading upward. Put a 1/2" x 24" long copper pipe section (or appropriate pipe to copper tubing sweat adaptors with copper tubing) on the vertical rise with the pressure switch mounted on top of the copper pipe (tubing). The idea is for the stainless to reduce possibility of switch getting too cold to "freeze" or distort and the copper should dissipate "cold" passing the stainless barrier. Lathrop management will install and test this switch and suggested piping.

Standard vapor dispersal tanks (92483D) are only 500-gallon units at other locations. Assuming there is 450 gallons capacity after the level switch has sounded the alarm, there should still be about 4 1/2 minutes for operator - loader to respond if rate is 100 GPM. Individual location load rates and distance

APCI DOCUMENT NO. 9900218

Air Products and Chemicals, Inc.

PUT IT IN WRITING

Date March 22, 1971

To W. J. Scharle Subject Lathrop Auto-Load System

From H. H. Master

( ) Take Action ( ) For Your Approval ( ) For Your Info ( ) Discuss With Me

( ) For Your Comments ( ) As Requested ( ) File ( ) Note & Return

relationships of various facilities will have to be considered to determine if the time allowance of a 500-gallon tank is sufficient.

Management here has put a lot of thought into this system and are to be commended for the work. It is the writer's opinion it is a workable system and after the system is complete according to the above and attachment details, we should give it several months trial and consider it for other locations.

H. H. Master

HHM:ejy
Attachments

LATHROP LOADING SYSTEM

OPERATION

Electrical system is connected by plugging coil-cord line (9,10,11) connection provided in rear loading compartment. System is 24-volt to preclude some hazards which may be associated with higher voltages, particularly with oxygen.

Turnon power on station switch (7). Lift lever on solenoid (6). If power is not on the solenoid valve will not stay open.

Opening of solenoid will provide instrument air to fill valve actuator (4) to open the fill valve (5). If there has been any reason that air is not supplied the fill valve will not open as the valve is fail-close.

With instrument air to the actuator the pressure switch (13) is also satisfied to turn on red light in the control room to indicate trailer is filling.

When loading is complete, the Barton switch (8) deactivates the solenoid venting the instrument air pressure on the valve actuator and the valve closes. Loss of pressure also opens the circuit on the pressure switch and turns out the red light in the control room advising the operator the tanker is full.

If automatic shutoff system does not operate the liquid will go to the vapor dispersal tank where the level switch (1) will actuate at 5" H_2O pressure (level) and activate the local alarm and scam system light and alarm in the control room. The operator will have about 8 minutes to get to the area to shut off the system manually (average load rate is a little less than 100 GPM).

In the event of problems with any of the fill valves (4) they can all be closed by cutting power to the solenoid with switches in the control room or the load area analyzer house. Valves off the storage tanks or the tanker itself can be shut manually if necessary to stop filling if malfunction of automatic system is not readily rectified.

1. Custom components pressure switch, Series 675 set at 5" H_2O

2. United Electric temperature pressure switch, type ~~B27A~~ E27A Model 84B, Range -50° to +50°F.

3. Coppus blower, Vano, design B (our standard now is Coppus, TM4, 1700 CFM -350) L. Bockenger made. E is remote mount.

4. Foxboro valve operator, Model P-50, Fail Close, 1 1/2" stroke, 0-20 psig pressure full open.

5. Powell Valve, 3" sweat fitting, type A 9692 Teflon plug insert, brass seat

   NOTE: Original valves were used at this location and actuators were adapted to the valves. Modification work done was:

   a. The extended stem bonnet was shortened to 10"
   b. The bonnet threads were machined out and a brass guide inserted in the bonnet bottom.
   c. The stainless steel stem threads were machined off
   d. The stainless steel stem top end was machined and threaded to screw into the operator lower end.
   e. One adaptor was machined to adapt the operator to the bonnet. See sketch.

6. Solenoid valve, Asco, type WP 8308, B84, 3/4"

7. Killar on-off switch, FST, all weather

8. Barton level gauge, model 288A with actuator, model 224 (snap acting)

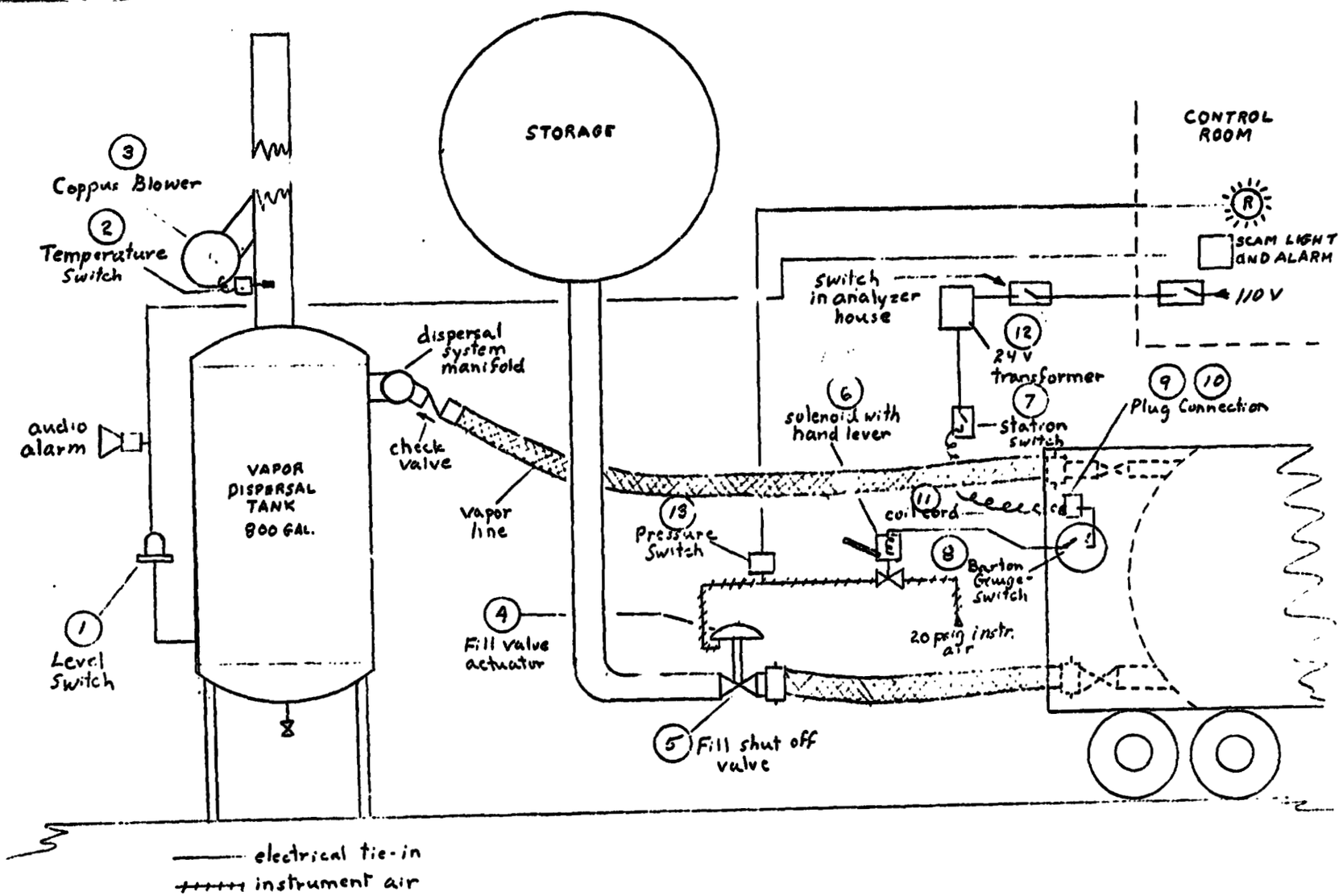
9. Hubbel electric plug, male, 3 pin twist lock

10. Hubbel electric plug, female, 3 pin twist lock

11. Flex cord, 16/3 type SJO, 300V

12. Jefferson transformer 500 XA, 24V

13. Custom Component., Inc. pressure switch, series 608, set to 10 psig.



LATHROP LOADING SYSTEM

3/22/71
Hillister

Air Products and Chemicals

PUT IT IN WRITING

Date April 5, 1971

To W. J. Scharle Subject Auto Load Systems

From H. H. Master

( ) Take Action ( ) For Your Approval ( ) For Your Info ( ) Discuss With Me

( ) For Your Comments ( ) As Requested ( ) File ( ) Note & Return

cc: W. L. Ball
B. J. Berrettini
J. P. Desnouee
M. H. Halsted
E. J. Isaacson
F. K. Kitson
A. W. Norman
B. Trammell
H. E. Wynn

On March 25, 1971, the writer met with A. Norman to discuss electrical circuitry and equipment for auto loading systems. Among other things, the writer was inclined to favor tieing in the dispersal tank level switch to shut down the stack blower and close all the fill valves.

As a result of this meeting, the following general revisions are to be considered for a standard system:

1. The existing lever-solenoid (Asco, Type WP 8308, B84, 3/4") is not reliable. A. Norman stated that we have had problems with this type at a num ber of locations where it is used for various other services. They hang-up similar to the one incident at Lathrop. With the outdoor service, the malfunction possibilities are increased. Alternate solenoid is listed on the attached equipment list.

2. It is believed it would be better to tie in the control room indicating light with the solenoid electrical circuit (as Lathrop originally had done) rather than install a pressure switch on the instrument air line to the valve actuator. This is particularly true with the different solenoid valve which could not be open unless there were power to the circuit The pressure switch to the light would tell you nothing more than that you have pressure to the valve which would already be known before leaving the area and we have the added expense and possible malfunction and maintenance on the switch. With the tie into the solenoid, it would indicate there is power to the solenoid and if the valve in fact did not open, there would be no hazard but merely a loss of fill time.

3. The dispersal tank level swtich should shut down the stack blower if we ever get a shutoff system failure and start getting liquid in the tank. With this setup, we would reduce the possibility of LOX filling up the tank and getting into an operating blower if the loader would not get to shut off the malfunctioning system in time.

4. The vapor dispersal tank level switch will also be wired to shut all station valves in the event of an overflow into the tank. It will not be necessary to run extra conduit and a lot more wire as the switch circuit can be tied into the main power for the entire system. With this arrangement, there is always the possibility the malfunctioning valve willclose if there was a problem in the electrical circuit. If it is a mechanical problem which prevented the valve from closing other methods will have to be initiated by the operator but meantime all other stations will have their valves closed so he does not have to worry about them.

APCI DOCUMENT NO. 990002412

Air Products and Chemicals, Inc.

PUT IT IN WRITING

Date April 1, 1971

To W. J. Scharle Subject Auto Load Systems

From H. H. Master

( ) Take Action ( ) For Your Approval ( ) For Your Info ( ) Discuss With Me

( ) For Your Comments ( ) As Requested ( ) File ( ) Note & Return

5. The vapor dispersal tank level switch will also remain on a local and control room alarm system as it is at Lathrop.

6. A 3-position selector switch with "Hand", "OFF" and "AUTO" points will be installed. The "AUTO" position of course will be the normal position for filling the trailer. The "hand" poisition will be used to open the valve when it is necessary to "top off" a tanker. When on "Hand", a red light will be lit. Operators will be instructed never to leave the area with a red light on as the valve is held open with the selector at this setting.

Attached are copies of the wiring diagram and equipment list prepared by A. Norman. Naturally, the relay systems will vary in number according to stations at each facility. We can standardize on a local panel box for each station which can be prewired and shipped as a unit ready for external connection to power and the solenoid valve.

H. H. Master

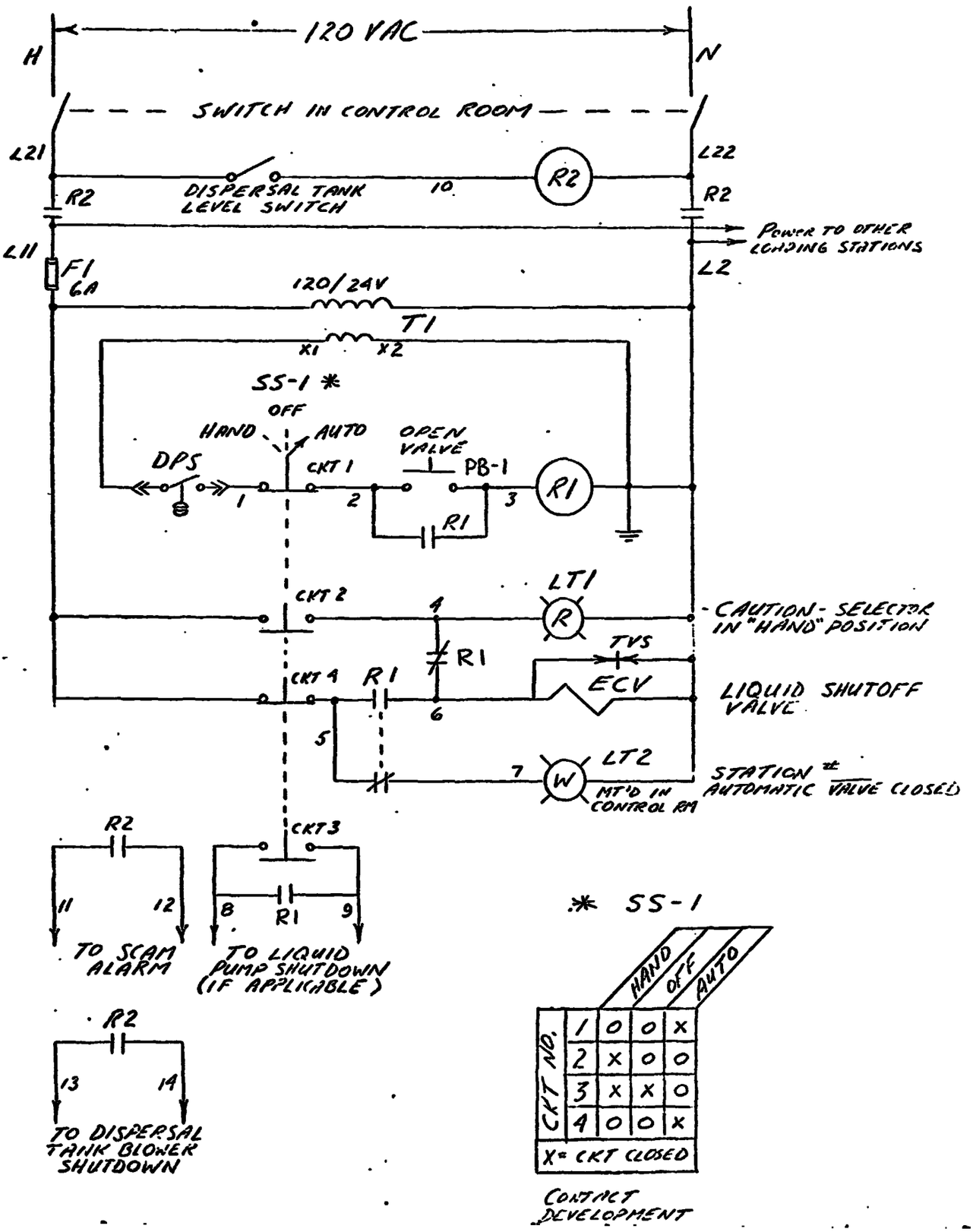
HHM:ejy
Attachments

FORM NO. 8100

Air Products and Chemicals INC.

BY AW71 DATE 4-1-71 SHEET NO. 1 OF 1

SUBJECT AUTOMATIC LIQUID LOADING STATION JOB NO.



* SS-1

CKT NO.	HAND	OFF	AUTO
1	0	0	X
2	X	0	0
3	X	X	0
4	0	0	X

X = CKT CLOSED

CONTACT DEVELOPMENT

- AUTO LOADING SYSTEM -

BILL OF MATERIAL

n No.		Qty. Per Station	Qty. Pe Facilit
1.	a. Indicating Light, Resistor Type, Type T Oil Tight, White Glass Lens, 120 VAC, C-H #10250T201C12 b. Legend Plate, Jumbo Size, C-H #10250TJ36 Engraved as Shown Below with 5/32 Inch Letters Pos A Station #(1 thru Qty. Ordered) Pos B Automatic Pos C Valve Closed	1 1	0 0
2.	Selector Switch, Assembled, Type T Oil Tight, 3 Position Maintained Contact, Lever Operator, C-H #10250T3029-23K58X	1	0
3.	a. Indicating Light, Resistor Type, Type T Oil Tight, Red Glass Lens, 120 VAC, C-H #10250T201C7 b. Legend Plate, Jumbo Size, C-H #10250TJ36, Engaraved as Shown Below with 5/32 Inch Letters Pos A - Caution - Pos B Selector In Pos C Hand Pos.	1 1	0 0
4.	Relay, 5 Pole, 10 AMP Contact Rating, 24V 60HZ Coil, 4 N.O., 2 N.C., C-H Type M-300 Multipole Relay Cat. No. D23MR42T	-	0
5.	Relay, 4 Pole, 15 AMP Contact Rating, 110V 60HZ Coil, 4 N.O. Contacts, C-H Type BC Control Relay Cat. No. 9575H2216	0	1
6.	Solenoid Valve, 3 Way, 1/4" Pipe Size, ASCO #830281RF	1	0
7.	Transient Voltage Suppressor GE 6RS20SP4B4 120 Volts RMS Input	1	0
8.	Low Voltage Control Transformer, Primary Volts 120, 60 HZ, Secondary Volts 24 Volts, 100 Volt-AMPS Capacity, Jefferson #637-261	1	0
9.	Fuse Block, Single Pole, 30 AMP, 250 Volt, C-H Type A, Cat. No. 10982-H1	1	0
10.	Fuse, 250 Volt, Buss Fusetron #FRN 6-1/4	1	0
11.	Portable Cord Connector, Watertight, Strain Relief Type, for .560 OD Cord, 3/4 Inch Hub Size, T & B #2534	1	0
12.	Retractile Electrical Power Cord, 20 Feet Long Extended, 48 Inches Retracted, 3 Conductor, AWG #14 Stranded, UL Type SO, (Jacket OD .560")	1	0

- AUTO LOADING SYSTEM -

BILL OF MATERIAL

Item No.		Qty. Per Station	Qty. Faci
13.	Myers Scru-Tite Fitting, 3/4 Inch Conduit Size Cat. # ST-2	5	3
14.	Crouse-Hinds Arktite Plug, 30 Ampere, 2 Wire, 3 Pole, Style 2, for .500 - .875 Dia. Cord, Cat. # APJ 3363 *	1	0
15.	Hoffman NEMA 12 Panel Enclosure, 16 x 12 x 8 Inches, Cat. No. A-161208 Including 13 x 9 Removable Panel	1	1
16.	Control Valve, 3 Inch, Bronze per APCI Spec.	1	0
17.	Pushbutton, Momentary Contact, Oil Tight, 2 N. O. Contacts, C-H 10250T111-21126	1	0
13.	Terminal Block, 12 Point, 30 AMP, 600 Volt, with Screw-Type Terminals and Marking Strip, C-H #10987-H7-1	1	2
19.	Terminal Block, 6 Point, 30 AMP, 600 Volt, with Screw-Type Terminals and Marking Strip, C-H #10987-H5-1	0	1

*IGD Note: This Plug Mates with Crouse Hinds, 30 AMP, 2 Wire, 3 Pole, Spring-Door Receptacle Cat. No. ARRH 3322

:N:sls

Air Products and Chemicals INC.

SAFETY - GRAM

August 10, 1962
Number 17

A MISTY PROBLEM

Vapor Clouds from Defrost Operations Allegedly Caused Highway Accident

On two occasions in the past six months, vapor clouds from vent stacks or liquid disposal systems allegedly have obscured public highways in the vicinity of generating facilities; and, according to insurance claims, have caused several vehicle accidents with resultant personnel injury. Air Products is now faced with possible legal action arising from these claims which allege negligence on our part as causing or contributing to the accident.

Normally, we might not expect product vapors to present any safety problem to public or private property adjacent to APCI facilities because of care in equipment design and plant layout. Climatic conditions, however, are variable and uncontrollable and may cause vapors to settle. During these unusual conditions, public and private property may be exposed to a hazard for which APCI will be held responsible.

Supervisors and shift foremen must be alert during defrost and liquid disposal operations to the direction of the vapor flow. If it is apparent that highways, public, or private property are going to be involved, discontinue operations to eliminate the hazard and resume when conditions are again normal. Review liquid disposal systems to determine if improvements can be made to minimize the vapor problem. If necessary, warning signs should be posted to alert the general public to the possibility of the vapor hazard.

Excess vapors may also be a problem during loading or unloading of a liquid tanker, particularly if a warm tank is involved; also if a tanker is involved in an accident and the tank or piping is ruptured. In these events, prompt action by the driver is required to control the rate of transfer or to suitably warn and control traffic that may be involved.

SAFETY DEPARTMENT
WWSchmoyer/WLBall/jmf

APCI DOCUMENT NO. 990002SD

PRODUCT VAPOR HAZARDS

H. H. Master

Product vapors can cause a number of hazards. Tanker loading operations are one of our most frequent sources of such problems. Each location, climatic conditions, type product, adjacent equipment, and employee or third party involvement must be considered in these operations. The attached pictures, sketch, article, and general rules are some of the guidelines and information to consider in eliminating exposure to yourself, the public, your fellow employee and the customer - not to mention the property of same.

APCI DOCUMENT NO. 9900251

SAFETY INFORMATION RELATIVE TO LIQUID-VAPOR CLOUDS

Over the years there have been a number of incidents within the company and related industries where vapors have caused accidents involving company personnel and third parties. Some reasons for the accidents include excessive vaporizing due to loading (particularly with a warm tanker), accidental spills and dumping liquid for tanker conversions or disposal of off-specification product.

There are a number of factors which can vary the hazard potential. Two of the most important are wind direction and velocity. The wind direction, of course, would influence the direction the vapors would move and the wind velocity the rate of dispersion. The properties of the gas would be a factor on diffusion rate. The direction of the wind should be considered as it is your first consideration as to whether personnel, equipment, or traffic may be influenced by the cloud. Although the velocity may help the dispersion, it can also increase the hazards as it could carry the vapors farther. One of the worst situations would be a high humidity condition with little or no wind. The heavy vapors tend to "hug" the ground and can spread farther than one may expect. One incident under such conditions caused two separate accidents on a public road approximately 300' from the loading area and on the side opposite the liquid storage building.

In addition to the hazards created by visibility restrictions, there are also the concentrations of products in the atmospheres. Degree and type of hazard will vary with the product involved. Of our most common products, the oxygen would increase the potential of a fire hazard, nitrogen or argon could result in asphyxiating atmospheres, and hydrogen or natural gases could create asphyxiating and flammable possibilities. Properties of the products will influence the potential hazard exposure but with the low temperatures involved, there will always be some possibility of the vapors "hugging" the ground.

A number of experiments have been run to determine the purities of atmospheres within a vapor cloud. Most of this work has been done with oxygen, but has some application to all cold vapors. Generally, the atmosphere outside of the vapor cloud will be air (21% oxygen) and inside the cloud, the atmosphere will vary from 21% oxygen to 100% oxygen on oxygen vapors or 21% oxygen to 0% oxygen for other products. The extremes (100% or 0% oxygen) in both cases would probably be limited to liquid spills with the purity taken immediately above the liquid pool. However, we must bear in mind that any oxygen concentration above 21% increases the combustibility to a considerable degree. Reduced oxygen content results in asphyxiation

possibilities. Safety Gram #28 outlines these symptoms in low oxygen atmospheres:

Oxygen Content	Signs and Symptoms
12% to 14%	Respirations deeper, pulse up, coordination poor
10% to 12%	Respiration fast and shallow, giddiness, poor judgement, lips blue
8% to 10%	Nausea, vomiting, unconsciousness, ashen face
6% to 8%	8 minutes - 100% fatal; 6 minutes - 50% fatal; 4-5 minutes - all recover with treatment
4%	Coma in 40 seconds, convulsions, respiration ceases, death

Oxygen concentrations of less than 4% will cause unconsciousness and/or death within ten seconds or just a matter of several breaths. The above symptoms will vary with the individual's physical condition and activity within the varying atmospheres.

Present corporate safety rules do not permit entry in oxygen deficient areas lower than 18% oxygen or concentrations above 25% without wearing proper protective equipment and following specific procedures.

As you can see, a considerable amount of judgement is necessary in determining working atmospheres and influence of climatic conditions in dispersal of vapor clouds to a point where it is safe for personnel, equipment and traffic within company bounds and outside our facility limits. Oxygen analyzers ("sniffer" type) are available at all our facilities, but obviously it would be impractical to use them all the time and after-the-fact applications may be too late. The 18% to 25% oxygen safe range is generally applied where we have some definite controls, such as entry into vessels. For load-unload applications, the best safety rule is to limit the cloud to the immediate area of the vent (and away from personnel) by controlling the venting rate or utilizing vent systems directing vapors to remote areas.

Attached are pictures and a sketch of a recent incident where a driver dumped LIN at high rate when there was essentially no wind and high humidity conditions. Fortunately, there were no accidents as a result, but the cloud did approach a public road, a supervisor ran through the cloud to stop the operation, and several motor vehicles were included in the vapor blanket. Oxygen or flammable gases would have created even more of a hazard under similar conditions. All pictures were taken from essentially

the same point indicated by the figure. The numbers and arrows from the sketch figure relate to three of the picture numbers. Picture 4 shows the source tanker with a slight vapor cloud after the individual was warned to limit the dump. On the sketch, this is the rig parked at an angle to the top, left of the three spotted tankers.

Also attached are copies of an incident involving LOX vapors at the John F. Kennedy Space Center. This article from the Fire Journal, January 1971, gives you some idea what can happen with the right concentrations at the wrong time or place. In this case there were facilities for liquid disposal, the cloud was relatively small, and personnel in general were knowledgeable, but a set of unusual circumstances resulted in considerable property damage and personnel exposure although no one was hurt in this case.

There are a number of safety procedures in manuals, standards and safety grams relative to this problem. A summary of these rules and a few others are listed below:

1. Some locations have vapor dispersal systems (manifolds to stacks at more remote locations) installed because of extreme climatic and/or personnel and public exposure. Some of these stacks have blowers attached which mix ambient air with the effluent gases to assist in dispersal of vapors by warming it and to reduce product concentration purities. All tankers at applicable facilities must be fitted with vent system fittings and must be connected so vapors are directed to the vent stack. Even vent stacks without blowers may require curtailed load rates, particularly with extremely adverse climatic conditions or when filling a warm tanker. "Foreign" tankers frequenting these facilities shall be requested to install fittings for our vent systems. If they do not comply, they shall have flow rates curtailed as necessary and require their drivers on standby at all times during loading.

2. Flow rates must be adjusted to limit vapors in the loading facilities where there are no vent stacks. This is particularly true when filling a warm trailer where there will be more boil-off.

3. Overfilling will result in liquid from vents and shall be avoided.

4. Repair leaking lines, valves, or equipment as necessary. Replace fill line gaskets as required.

5. Do not start an engine or drive a motor vehicle in a heavy concentration of venting gases. Fuel is always present in the form of oil and grease accumulations on the engine, and the insulation of the electrical system. Ignition can take place due to frayed insulation resulting in an electrical spark or a hot exhaust manifold. If a parked vehicle is exposed to oxygen or flammable gas vapors, do not start the engine until the hood has been lifted,

ventilated, and checked with an appropriate analyzer.

6. Compartments of vehicles and loading areas shall be kept tidy and clear of combustible materials.

7. Observe "No Smoking" regulations in loading areas.

8. If you have been exposed to concentrations of venting oxygen or flammable gases and clothing cannot be changed, do not smoke for at least one-half hour until the gas has dissipated. Remain in a well ventilated area and slap clothing to assist dispersion of oxygen vapor from clothing. There was an incident a few years back when ten men were involved (one seriously) in a fire caused by one man lighting a cigaret in a smoking area where an unsuspected oxygen enrichment existed as a result of a previous LOX dump in the general area. The other men suffered some burns when they caught fire trying to put the first one out.

9. Pipelines, trenches, sewers, etc. must be considered. Vapors can accumulate in sewers and spread to other areas where the ignition potential is possible. Also, liquid on or in pipelines or transportation equipment can cause fractures as carbon steels, plastics, and some other construction materials become brittle and can fracture easily at temperatures below -20°F. Pipelines in high pressure service could have catastrophic results if they were fractured. Freezing of water or other service lines can present other problems. Company facilities avoid such problems at loading areas but customer loading facilities may not always be so inclined. When selecting a dump area on APCI facilities, this point must be kept in mind.

10. Dumping of off-specification or tanker conversion liquid shall be done in a clean, safe area. Some of the considerations are listed above. Facilities with dispersal system tanks (usually limited to 500 gallons) shall dump the liquid in the tank. Be sure the area is clean. There is a fatality recorded where oxygen was drained in a "dirty" ground area and when a high pressure air line was blown down in the same spot, they had an explosion which created a crater about two feet in diameter. "Shrapnel" struck one of the operators in his chest resulting in his death.

11. All personnel involved in loading, handling, or transportation of cryogenic liquids shall be familiar with the properties of the products. Information is available in various safety manuals at all Operations sites. Other material or additional copies are available through the Operations Safety-Service Manager or Safety Department.

1



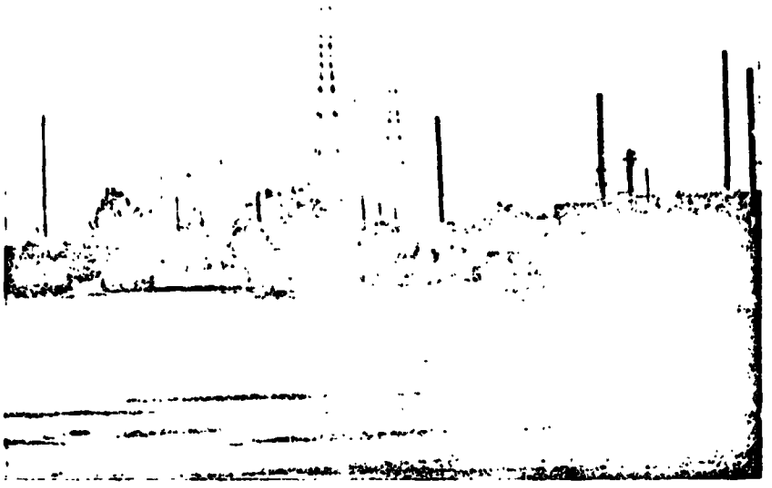
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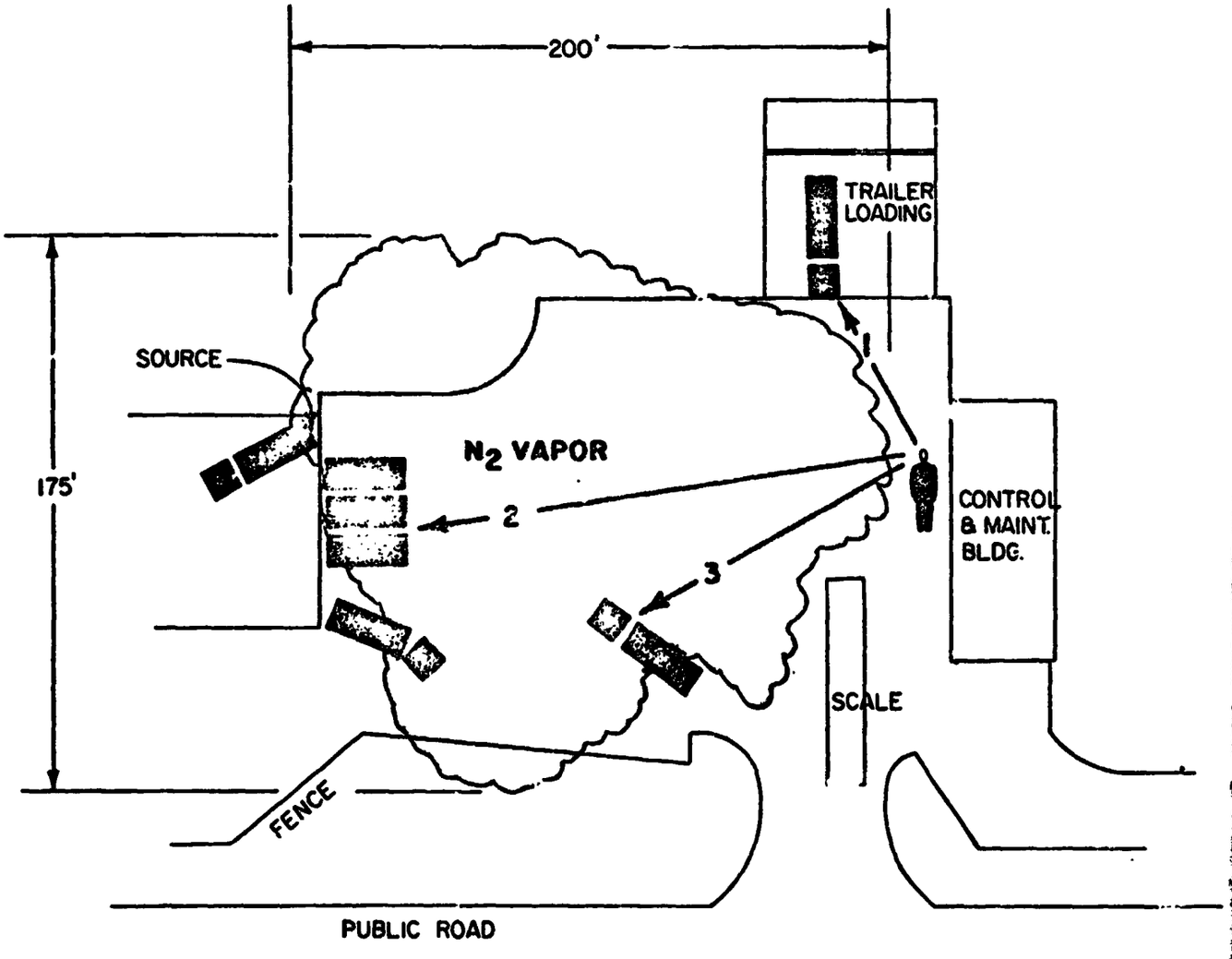


3



4




200'
TRAILER LOADING
SOURCE
175'
N_2 VAPOR
1
2
3
CONTROL & MAINT. BLDG.
SCALE
FENCE
PUBLIC ROAD

Air Products and Chemicals INC.

NASA

KENNEDY

FIRE INCIDENT IN AN OXYGEN CLOUD

by

John B. Gayle

Fire Journal PP76-8 and
81 4P, January, 1971

APCI DOCUMENT
#0 22000352

INDUSTRIAL SAFETY POLICY

Based on Section 625.0.1, Safety Standards.

I. PURPOSE

To establish a standard procedure for safety policies and practices and safe working conditions.

II. RESPONSIBILITY

A. Senior Management shall be responsible for the inception and effectiveness of the safety program throughout the company.

B. The Safety Department shall be responsible for the establishment of corporate safety policy and practices. It shall also periodically review the safety program at each facility.

C. The Department Manager shall be responsible to Senior Management for all accidents resulting from activities within his department and for the effective operation of the safety program in his department.

D. The Regional Manager shall be responsible to the Department Manager for all accidents resulting from activities within his region and for the effectiveness of the safety program in his region.

E. The Plant Manager shall be responsible to the Regional Manager for all accidents resulting from activities within his plant and for the effectiveness of the safety program within his plant.

F. The Assistant Plant Manager (foreman, shift supervisor, etc.) shall be responsible to the Plant Manager for all accidents resulting from activities under his supervision and for the effectiveness of the safety program in all operations in which he may be involved.

G. From time to time it is necessary to set up special groups or task forces to handle particular problems, such as special engineering projects or construction activities. The supervisors at the various levels within these groups shall operate under the basic philosophy that safety is a line function. They shall be responsible for all accidents resulting from activities within their jurisdiction and for the effectiveness of the safety program at their levels.

APCI DOCUMENT NO. 99000 252

INDUSTRIAL SAFETY POLICY

Based on Section 625.0.1, Safety Standards.

III. PROCEDURES

A. Senior Management acts to prevent accidents and improve the effectiveness of the safety program throughout the corporation. It shall:

1. Provide the direction and motivation to ensure a dynamic corporate safety program.

2. Delegate each Department Manager the authority to provide safe equipment and a safe working environment in his department.

3. Consult with the Safety Department in the interest of constantly improving the safety program.

4. Review reports and analyses from the Safety Department for the purpose of evaluation of the safety program.

B. The Safety Department shall maintain a staff relationship with every department of the company. It shall:

1. Formulate corporate safety policy and establish the basic safety program.

2. Perform periodic safety inspections at all company facilities, report on conditions there, and recommend remedial action where necessary.

3. Distribute safety information to all departments of the company.

4. Review and analyze safety reports from the various facilities and make recommendations when necessary.

5. Compile statistics with regard to the frequency, severity, and causes of accidents and recommend corrective action to management.

6. Be available to all departments for consultation on safety problems.

C. The Department Manager shall perform the following duties:

1. Delegate authority for control of accidents to the Plant Manager reporting to him.

INDUSTRIAL SAFETY POLICY

Based on Section 625.0.1, Safety Standards.

2. Amplify and clarify procedures for his own department.

3. Consult with the Safety Department in the interest of constantly improving the safety program.

4. Review reports and analyses from the Safety Department for the purpose of evaluation of his safety program.

D. The Regional Manager shall direct the safety program within his region. He shall:

1. Delegate authority for administration of the plant programs, including control of accidents, to the Plant Managers.

2. Delegate to the Safety Supervisor (if such a position is included in his organization) or Plant Manager the authority required for an effective and dynamic safety program within his region.

3. Consult with the Safety Department in the interest of constantly improving the safety program.

4. Review all aspects of safety with the Safety Department and each Plant Manager.

5. Review the Monthly Summary of Injuries (Form 2021) with each Plant Manager.

E. The Plant Manager directs the safety program within his plant. He shall:

1. Delegate authority to Assistant Plant Managers (shift supervisors and foremen). Each Assistant Plant Manager should be given the authority to administer the safety program, including the control of accidents, within his area of responsibility. The Plant Manager should consult with Assistant Plant Managers often on problems relating to the program.

2. Delegate to the Safety Supervisor (if there is one at his plant) the authority required for an effective and dynamic safety program within the plant.

INDUSTRIAL SAFETY POLICY

Based on Section 625.0.1, Safety Standards.

3. Hold at least one safety meeting a month at all locations where manufacturing and operations activities and performed. Representatives of both hourly and supervisory employees shall attend the meeting on a rotating basis. Minutes of the safety meeting (Form 2030) must be prepared and distributed after each meeting.

4. Investigate all accidents with the responsible supervisor, report accidents to the Regional Manager, and take emergency action when necessary.

5. Keep equipment in prime operating condition, and establish and maintain a safe housekeeping program.

6. Inspect the plant monthly, using the Monthly Plant Safety Survey (Form 2032) as a guide.

7. Maintain the following accident reports, which are submitted by the Assistant Plant Managers. These forms are described and illustrated in Section 5.18 of this manual.

   a. First Aid Report (Form 2019)

   b. First Report of Accident (Form LC-2680; in Florida, use Form LC-3621)

   c. Supervisor Accident Investigation Report (Form 2020)

   d. Near Accidents, Unsafe Practices or Conditions (Form 2023)

8. Prepare and submit a Monthly Summary of Injuries (Form 2021).

9. Perform a monthly contaminant test and report results on Form 2033, Monthly Report of Contaminant Testing. Reporting requirements are detailed in Section 5.18 of this manual, Safety Reports and Forms.

F. Each Assistant Plant Manager (shift supervisors and foremen) shall work personally with the employees in his section to give each employee a keen awareness of his personal responsibility for safety on the job. Under the supervision of the Plant Manager, the Assistant Plant Manager shall incorporate safety tasks into his principle duties. He shall:

INDUSTRIAL SAFETY POLICY

Based on Section 625.0.1, Safety Standards.

1. Teach employees that accidents are caused and can be prevented; each employee should be taught the hazards of his own job and the ways to avoid them.

2. Convince each employee that violation of safety rules will not be tolerated.

3. Provide appropriate safety equipment and protective devices for each job.

4. Give full support to all safety activities and procedures.

5. Conduct safety appraisals of his section, including a careful inspection of new and relocated equipment before it is used.

6. Correct unsafe conditions promptly and prevent repetition of unsafe acts.

7. Investigate and find the causes of all accidents, even those which result in only minor injuries.

8. See that all injuries are reported and properly treated.

9. Prepare and submit the following reports to the Plant Manager. These reports are described in Section 5.18 of this manual.

   a. First Aid Report (Form 2019)

   b. First Report of Accident (Form LC-2680; in Florida, use Form LC-3621)

   c. Supervisor Accident Investigation Report (Form 2020)

   d. Near Accidents, Unsafe Practices or Conditions (Form 2023)

G. Executive Safety Council

1. Membership. All members of the Council are permanent members except the representatives listed as item d, below, who are rotated, with one new member named each quarter. The members include:

INDUSTRIAL SAFETY POLICY

Based on Section 625.0.1, Safety Standards.

a. Senior Management Member (Chairman)

b. Safety Director

c. Personnel Director

d. Four representatives of major departments or divisions.

2. Activities. The Executive Safety Council shall:

a. Meet each quarter.

b. Determine actions to be taken on accident control problems indicated by the Safety Director's analyses and reports.

c. Prepare directives for the President, indicating specific measures necessary to improve the safety program. These will be issued to Regional and Plant Management personnel.

d. After each meeting, submit to the President a report of the progress of the safety program.

IV. RELATED PROCEDURES

1.01, Index of Safety Reference Literature

5.18, Safety Reports and Forms

5.21, Accident Reporting

Operations Safety Manual (pocket-sized)

Safety Standards, Section 625.0.1, Industrial Safety Policy

V. RELATED FORMS

NOTE

For descriptions and samples of the following forms, see Section 5.18, Safety Reports and Forms.

INDUSTRIAL SAFETY POLICY

Based on Section 625.0.1, Safety Standards.

2019, First Aid Report

2020, Supervisor Accident Investigation Report

2021, Monthly Summary of Injuries

2023, Near Accidents, Unsafe Practices or Conditions

2030, Minutes of Safety Meeting

2032, Monthly Plant Safety Survey

2033, Monthly Report of Contaminant Testing

LC-2680, First Report of Accident

LC-3621, First Report of Accident (Florida only)

Air Products and Chemicals, Inc.

CORPORATE ADMINISTRATIVE PROCEDURE

ACCIDENT REPORTING

Number 1.5
Issued 4/1/68
Effective 4/1/68

Supersedes 9/5/63

I. **PURPOSE**

To establish a standard procedure for all accident reporting and processing.

Rev. II. **DEFINITION**

A. Accident, as used in this procedure shall consist of the following:

1. All events and occurrences resulting in loss or destruction of APCI property, wherever located.

2. A "lost-time" injury to or death of APCI personnel while on duty or in travel status on company business.

3. Loss or destruction of property.

4. Injury to or death of third persons -

a. while on APCI property

b. resulting from or relating to property or products owned, manufactured or sold by APCI

c. due to conduct of APCI personnel, contractors, or subcontractors

B. Accident, as used in this procedure, is not intended to include maintenance shut-downs of a plant, repairs of deteriorated equipment, road service for vehicles, etc., nor shall it relate to the employee group insurance plan.

III. **RESPONSIBILITY**

A. The Plant Manager or Supervisor of the facility at which an accident occurs is responsible for:

Rev. 1. Reporting the accident in accordance with his particular Division Standard Operating Procedure. These procedures must cover phone reports to the following:

a. The Division Manager (through appropriate line responsibility)

b. The Corporate Safety Director

c. The Insurance Manager

d. The Manager of Public Relations

e. The Corporate President (not more than 24 hours after the accident)

f. The Vice President of the Law Department must be notified in all cases involving personnel or property of third parties (customers, general public, etc.)

APCI DOCUMENT NO. 99000254

g. The Manager of Personnel Administration must be notified in all cases involving "lost-time" injury or death of APCI personnel.

h. The Insurance Carrier's local office - For certain types of accidents the Insurance Manual states which insurance carrier must be notified immediately.

In the absence of Division Procedures contact the Division Manager through appropriate line responsibility and the Corporate Safety Director as soon as practicable. The Corporate Safety Director will then notify the necessary Corporate Management.

NOTE: In cases of accidents involving personnel "lost-time", third party personnel and equipment and major equipment damage (including vehicles) the initial contact will be made by telephone. For minor equipment damage (dented fender type accidents) the initial contact will be made through normal channels.

2. Taking any emergency action necessary to minimize the extent of the loss or damage.

3. Initiating any forms necessary to replace damaged property.

Rev. 4. In case of injury to an employee of another division, the injured employee's Division Manager will be notified.

Rev. B. The Divisional Manager is responsible for determining overall emergency strategy such as where and when damage is to be repaired, source of alternate product, etc.

Rev. C. The Safety Director is responsible for:

1. Investigating all accidents involving injury to third parties.

2. Investigating all other accidents as necessary.

3. In conjunction with the Department or Division involved, develop corrective measures to prevent recurrence of the accident.

4. Provide reports, information and technical assistance to the Insurance and Law Departments as necessary.

5. Compile accident statistics and data and prepare reports as required for management information and The Corporate Safety Program.

Rev. D. The Controller is responsible for the accumulation of cost information relating to the repair or replacement of property damaged or destroyed by the accident and for the recording and disposition of Insurance Claims upon notification of the Insurance Department.

E. The Vice President of the Law Department is responsible for rendering legal assistance to the Insurance Manager in connection with claims from third parties and as may be required on other claims.

Rev. F. The Insurance Manager is responsible for:

1. Determining whether or not an accident is covered by insurance in force.

2. Preparation, filing and negotiation of all insurance claims.

3. Notifying the Controller of the status of all insurance claims.

4. Preparation of loss experience data with respect to both insured and uninsured accidents.

Add G. The Manager of Public Relations is responsible for handling all press inquiries after coordinating the information with the appropriate Division Manager and clearing the information to be released through the Insurance Department, Law Department and other established channels.

Rev. H. All Department Heads must have a working knowledge of the Insurance Manual and the Safety Standards Manual and are responsible for their employees complying with the instructions contained in these manuals.

IV. PROCEDURE

Rev. A. All statements with respect to any accident made to anyone not connected with the Company will be handled through the Insurance or Public Relations Departments at Trexlertown after consultation with the Law Department. Any statements required to be made to the APCI Insurance Company representative or law enforecement authorities will be confined to the basic facts and further details must be cleared prior to release. No statement as to liability for the accident will be made to anyone not connected with the Company.

Rev. B. The procedures to be followed in regard to the individual reports to be completed for the Insurance Department and the Insurance Carriers are detailed in the Insurance Manual.

Add C. The procedures to be followed in regard to the individual reports to be completed for the Safety Department are detailed in the Safety Standards Manual.

Add D. The procedures to be followed in regard to the individual reports to be completed for Division Management are detailed in the Division Operating Procedures.

V. RELATED MATERIAL

APCI Insurance Manual
Safety Standards Manual
Division Operating Procedures

ACCIDENT REPORTING

I. PURPOSE

To establish a standard procedure for Operations Supervisors and Management to report accidents. This procedure is intended to supplement Corporate Administrative Procedure 1.5 and be definitive for the general areas in that Procedure so they are applicable to Operations Department reporting methods.

II. RESPONSIBILITY

Plant, Regional and Operations office managers are responsible for compliance with the provisions of this procedure as applicable.

III. PROCEDURE

A. Definition

1. Accident as used in this procedure shall consist of the following:

   a. All events and occurrences resulting in loss or destruction of APCI property, wherever located.

   b. A "lost time" injury to or death of APCI personnel while on duty or in travel status on company business.

   c. Loss or destruction of property.

   d. Injury to or death of third persons.

      (1) While on APCI property.

      (2) Resulting from or relating to property or products owned, manufactured or sold by APCI.

      (3) Due to conduct of APCI personnel, contractors, or subcontractors.

2. Accident as used in this procedure is not intended to include maintenance shutdowns of a plant, repairs of deteriorated equipment, road service for vehicles, etc., nor shall it relate to the employee group insurance plan.

APCI DOCUMENT NO. 9000255

ACCIDENT REPORTING

B. The Plant Manager will be responsible for:

1. Taking any emergency action necessary to minimize the extent of the loss, damage or injuries to personnel.

2. Contacting the Regional Manager and relating details of the incident.

3. Notifying Insurance Companies:

a. Written notification shall be made to Hartford Accident & Indemnity utilizing the form described in III, F-1 below in event of employee injury.

b. Hartford Accident & Indemnity shall be notified verbally in the event of injury to the person or property of the public. Written reports on the matter shall be done in accordance with III, F-3 below.

c. Prompt verbal notice shall be given to Maryland Casualty or the Factory Insurance Association in respect to damage to APCI propert or interruption of production. We can be penalized for late repor

4. Completing accident report forms outlined below. The Safety Insurance and Law Departments can be consulted in this area.

5. Initiating any forms necessary to replace damaged property.

6. In case of injury to an employee of another division notify the injure employee's Division Manager.

C. The Regional Manager will be responsible for:

1. Contacting Operations General Production Manager or Assistant to Vice President of Operations and transmit the details of the incident to them. If neither one of these parties can be contacted after work hours, the Operations duty man shall be contacted through the answering service. The duty man shall be advised to contact one of them or act their behalf as outlined below.

2. Determining overall emergency strategy such as where and when damage to be repaired, source of alternate product, etc.

ACCIDENT REPORTING

D. The Operations General Production Manager or the Assistant to Vice President of Operations will be responsible for:

1. Notifying the Corporate Safety Director, Vice President of Operations, and Manager of Public Relations. The Manager of Personnel Administration must also be notified in all cases involving "lost time" injury or death of APCI personnel.

2. Notifying the Purchasing Department with respect to potential warranty claims.

Note: The Corporate Safety Director will contact the Corporate President, Law Department and Insurance Department.

E. General

1. All statements with respect to any accident made to anyone not connected with the Company will be handled through the Insurance or Public Relations Departments.

2. The Insurance Section of the Treasurers Department will handle and direct claims to our insurers. Initiate notices as covered in III, B.

3. The Purchasing Department will direct warranty claims against vendors upon receipt of supporting technical data.

F. Forms and Reports

1. First Report of Accident Form (number will vary in different states, check with the insurance inspector or state authority). This form is to be filled out for any employee injury requiring medical attention over and above first aid. One copy shall be retained in the facility file, one copy shall be submitted to the local Hartford Accident and Indemnity Company office <u>if there are third parties involved</u>, one copy to the Treasurers Department (Insurance Section), one copy to Personnel Department, one copy to the Safety Department, one copy to the Vice President of Operations, and one copy to the appropriate State Workmen's Compensation Agency, if required (for lost time accidents where there is loss of work time beyond one shift).

2. Supervisor Accident Investigation Report (Form 2020, Exhibit A). This form shall be filled out as soon as is practical for every accident causing injury that involves "lost time," for any accident or injury, no matter how slight, which involves unusual circumstances. A copy shall be retained at the facility and a copy forwarded to the Vice President of Operations, Operations Safety-Service Manager and Safety Department.

ACCIDENT REPORTING

3. For third party incidents involving APCI's operations and products, a comprehensive written report shall be submitted promptly by the plan manager within whose jurisdiction the accident occurs. Final approval shall be made by the Corporate Law Department and distributed by them to interested parties.

4. In respect to damage to APCI property:

   a. APCI vehicle accident report

   b. All other property a comprehensive initial report and supplementar reports as advised or requested.

G. Personnel Contacts

Operations and Safety Personnel contacts are named in an appendix to this procedure for convenience when revising the procedure to reflect changes i personnel.

IV. RELATED PROCEDURES

5.03, Communications Concerning Emergency Shutdowns

5.16, Industrial Safety Policy

610.1.5, Safety Standard

APCI Insurance Manual

V. RELATED FORMS

2020, Accident Investigation Report (Exhibit A)

APPENDIX A

SAFETY AND OPERATIONS PERSONNEL CONTACTS

Safety Department

Person	Title	Office	Home
Ball, W. L.	Safety Director	215-395-7025	215-395-4131
Kitson, F. K.	Process Safety Engr.	215-395-7027	215-285-2121
Lutes, R. L.	Fleet Safety	215-395-7485	215-433-4049
Schmoyer, W. W.	Operations Safety Engr.	215-395-7026	215-797-5926
Smith, H. W.	Industrial Safety Engr.	215-395-7175	215-395-9812

Operations Department

Person	Title	Office	Home	Off Premise Extension
Master, H. H.	Oper. Safety-Service Manager	215-395-7357	215-797-3463	
Wynn, H. K.	Oper. General Production Manager	215-395-7354 7941	215-434-1425	7933
Scharle, W. J.	Asst. to Vice President of Operations	215-395-7151 7941	215-437-2844	7798

Air Products and Chemicals inc.

Section 5.21 - Exhibit A
Office Use

Non-Disabling ☐

Disabling (lost-time) ☐

Supervisor Accident Investigation Report

Name of Injured_____ Clock No._____Date of Injury_____

Age_____ Length of Service: With Company_____on Present Job_____

Occupation _____

Nature of Injury_____

Description of Accident

(This information is for use in preventing similar accidents. Answer questions specifically, as indicated by example.)

1. **What Job Was Employee Doing Including Tools, Machine and Materials Used?** (Example: *Lifting* a heavy casting onto a *four wheel truck*.)

_____

_____

2. **How Was Employee Injured?** (Example: The casting *slipped* from his *grasp* and *fell* on his toes.)

_____

_____

_____

3. **What Did Employee Do Unsafely?** (Example: Tried to lift *too heavy load*.)

_____

_____

4. **What Was Defective, In Unsafe Condition, or Wrong with Method?** (Example: Should have had *help*.)

_____

_____

5. **What Safeguards Should Be Used?** (Example: Wear *Safety Shoes*.)

_____

_____

6. **What Steps Were Taken to Prevent Similar Injuries?** (Example: Instructed men to assist each other in lifting heavy loads.)

_____

_____

7. **What Other Steps Should Be Taken to Prevent a Recurrence?** (Example: Provide mechanical handling equipment for this work.)

_____

_____

_____

Signed _____

Department_____

Plant _____

(Over)

For Office Use Only

(Enter as Facts become available)

8. Temporary Total ☐ **Permanent Partial** ☐ **Death or Permanent Total** ☐

Started losing time_____ **Part of Body**_____ **Time charge**_____

Returned to work _____ **Per cent loss or loss of use**_____

Time charge _____ **Time charge**_____

9. Compensation $_____ **Medical $**_____ **Other $**_____

OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

I. PURPOSE

To establish standard requirements for oxygen compressor systems.

II. SCOPE

This standard applies to all oxygen compressor systems designed and operated by APCI.

III. APPLICABLE GENERAL DESIGN ENGINEERING STANDARDS

A. Oxygen Compressor Location - See standard 570.6.

B. Personnel Protective Shield - See standard 546.1.

C. Field Testing, Centrifugal Oxygen Compressors - See standard 551.8.1.

D. Field Testing, Reciprocating Oxygen Compressors - See standard 552.8.1.

IV. DESIGN CRITERIA

A. Centrifugal Compressor

1. System

The schematic shown in figure 1 describes a standard arrangement for a centrifugal oxygen compressor system utilizing suction pressure control. The valve and instrument numbers used in this standard are keyed to figure 1. Although all centrifugal systems are to conform to the general scheme shown, variations are necessary to accommodate capacity requirements, manufacturers' differences, and method of flow control. See figure 2 for changes applicable to a mass flow control system. This system is normally utilized to achieve an optimum ratio of horsepower to product flow when the customer's process permits a constant oxygen delivery rate.

2. System Equipment and Piping

a. Compressor - See Design Engineering Standards 551.3.1.

b. Shell and Tube Exchangers - See Design Standards 557.2.1.

c. Lubrication System - See Design Engineering Standard 558.4.1.

d. Lube Oil Piping - See Design Engineering Standard 578.40.1.

e. Vent Silencers - See Design Engineering Standard 558.5.2.

f. Instrument Panel - See Design Engineering Standard 534.1.

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Date 7/19/71

OXYGEN COMPRESSOR SYSTEM **APCI OPERATED**

IVA2 (Cont'd)

g. Oxygen Piping Concept and Design Requirements - See the following Design Engineering Standards:

578.60.1 - Oxygen Piping
578.60.3 - CSO 1.5
578.60.4 - CSO 2.7
578.60.5 - CSO 5
578.60.6 - CSO 7.2
578.30.2 - SS 2.7
578.30.3 - SS 6
578.30.4 - SS 12
578.30.5 - SS 17
578.30.6 - SS 30
578.30.8 - SS 36
578.30.15- SS 7.2

h. Flanges shall be provided for removing suction, interstage and discharge piping for inspection of the compressor system.

i. Piping bellows and liners shall be 300 series stainless steel. Flange and nipple material for bellows assemblies shall conform to the piping material selected in accordance with standard 578.60.1, paragraph IV B 5.

j. Compressor suction piping, bellows, etc. shall normally be designed for a minimum of 55 psi above the maximum suction pressure or the maximum allowable working pressure of the compressor case, whichever is lower. Intent of this requirement is to permit suction rupture disc burst pressure to be greater than pressure surges during recycle.

Note: 1. Maximum suction pressure is defined as the maximum pressure normally maintained downstream of the suction throttle valve. This value is normally 5 psig for single compressors.

2. The compressor shall normally be procured with a suction side maximum allowable working pressure (MAWP) greater than the above design pressure for suction piping. See standard 551.3.1.

3. Where economical, the suction butterfly valve, the suction piping downstream of the valve and the compressor shall have a MAWP equal to the discharge pressure of the compressor.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA2 (Cont'd)

k. Where the oxygen source is liquid or a possibility of liquid carryover exists, the design of the suction piping shall provide a trap to prevent liquid carryover into the compressor or to carbon steel suction piping. Design requirements for product oxygen piping from distillation columns require a vertical loop high enough to prevent liquid carryover to the heat exchanger; therefore the oxygen compressor is protected from this source without any other equipment.

l. A single strainer shall be provided in the compressor suction line immediately adjacent to the case. Strainer shall conform to figure 3. It shall be sized to fit piping designed for economical pressure drop to the compressor. This design should normally result in pipe velocities below 150 ft./sec. at design flow.

A spool piece shall be provided in the suction piping to house the strainer. Spool piece shall be flanged on each end and shall be approximately 2 inches longer than the strainer.

Preservation of strainer screen integrity during installation is critical. Therefore, it is intended that the strainer will be positioned in and bolted to the spool flange with the spool in a vertical position, prior to installing spool in the suction piping.

m. Compressor piping shall include taps to permit the measurement of pressure drop across the suction strainer.

n. A 1-inch I.P.S. bypass line with a globe shutoff valve shall be provided around the suction throttle valve. This bypass is required for purging the compressor with oxygen and for starting the compressor on an oxygen-nitrogen mixture.

o. Where compressor bypass lines are provided, the bypass shall originate downstream of the cooler.

p. A check valve shall be installed in a section of the discharge piping located remote from the oxygen compressor to prevent backflow of oxygen in the event of compressor failure. The check valve shall be located outside the personnel protective shield in accordance with Design Engineering Standard 546.1. The check valve shall be selected for a minimum pressure drop.

q. Nitrogen Purge Piping

Adequately sized nitrogen piping (normally 2 inch) shall be permanently installed from a dry, oil-free nitrogen source to the compressor suction for start-up, run-in and shutdown of the compressor. This piping shall contain double block and vent valves to prevent contamination of either the oxygen or

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA2q (Cont'd)

nitrogen circuits. One of the double block valves shall be located close to the front of the oxygen compressor control panel to permit control of nitrogen flow while observing compressor pressures. Block valves shall be 2-inch ball type.

Additionally, double, in-line, tight-sealing, 2 inch check valves shall be provided between the block valves for all critical nitrogen supply situations. A single check valve is acceptable for noncritical nitrogen supply.

A $\frac{1}{2}$-inch check valve shall be provided on the outlet of the vent valve to prevent entrance of dirt, bugs and other foreign items. The check valve outlet shall contain a return bend or elbow as required to point downward to prevent entrance of rain. Vent piping material shall be copper, bronze, or stainless steel.

Two, 2-inch, ball type vent valves shall be provided, one before the upstream block valve and one after the downstream block valve, for use in performing an oxygen compressor test on a carbon dioxide and nitrogen mixture. These valves outlets shall be plugged when not in use.

All piping between the double block valves shall be of stainless steel, copper, or brass.

r. Lubrication systems shall be designed with local pressure gauges, thus requiring no tubing runs to the oxygen compressor control panel.

s. When the following compressor vents are incorporated in a manufacturer's design, they shall be piped outside the personnel shield to permit daily checks by operators. Piping shall contain no liquid traps and shall pitch downward at least $\frac{1}{4}$-inch per 3 feet throughout its length. Valves shall not be installed in these lines.

   (1) Dry sump drains.

   (2) Split line groove ports located just below horizontal split line. These vents shall be piped distant from the oil vapor vents indicated by "t" below, since the case vent gas could become high in oxygen content and oil contamination of these vents is undesirable.

t. Upper vertical breather ports from compressor dry sumps and couplings shall be piped outside the barrier to a collection bucket. Each breather shall be piped separately.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA2 (Cont'd)

u. Temperature reduction by adiabatic expansion from source pressure to use pressure shall be considered when selecting piping material for auxiliary equipment such as air motors, seal gas, etc.

v. Seal Gas System

Seal gas shall be air from the main air compressor which has been dried and warmed to ambient temperature by passage through heat exchangers. Since this stream is also used for instrument air and is normally connected to the air drier outlet stream, the seal gas stream shall be separated from the drier outlet piping by a check valve to minimize the possibility of drier desiccant migration to the seal gas system.

A backup seal gas system shall be provided utilizing nitrogen gas from the storage tank or bottles to provide adequate seal gas flow and pressure during oxygen compressor coast-down, should the main seal gas source fail.

A single filter shall be provided in the seal gas piping on the inlet side of each pressure reducing valve PCV-51 and PCV-53. Filter medium shall be stainless steel or bronze and shall pass particles no larger than 50 microns. Piping from the filters to the compressor assembly connection shall be schedule 40 brass with screwed ends. Brass or bronze screwed fittings shall be utilized. Control, check and hand valves shall have bronze bodies and bronze or stainless trim. Inlet piping to filters shall conform to Design Engineering Standard 530.3.1.

Note: These filters are required to remove any particles remaining after initial blowout of piping. They are required in addition to the desiccant filter to be provided immediately following the instrument air drier.

w. Cooling Water Systems

(1) Open System (cooling tower or pond)

(a) This system shall apply to the following equipment.

1 Intercoolers and aftercoolers.

2 Oil cooler.

3 Motor cooler.

4 Closed system water cooler.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA2w (Cont'd)

(b) Equipment and Piping

1 A ball type hand valve (3/4 inch I.P.S.) shall be installed at each end of the shell circuit at the low point. These two valves are to be used for shell side blowdown and water drainage.

Note: Valves shall be purchased by APCI for field installation.

2 A globe type flow control valve shall be located in the outlet line of each cooler upstream of the header piping. These valves will normally be located within the personnel shield.

3 Water flow sight glasses are not required for intercoolers and aftercoolers.

4 Air vent valves (½ inch) shall be installed at all high points in compressors and associated water-cooled equipment where air can be trapped.

5 In freezing climates, water header piping to and from coolers shall be valved to permit continuous water circulation during cooler maintenance. Therefore, a bypass valve (3/4 inch) shall be teed off the cooling tower side of each header shutoff valve at grade level. Each bypass valve shall be located within 6 inches of the corresponding shut-off valve. In case maintenance is required, a rubber hose will be temporarily connected between these two bypass valves. Additionally, a drain valve (½ inch) shall be located in the low point of each header to and from the coolers to permit drainage of all stagnant lines caused by shut-off valve closure.

(2) Closed System

(a) This system shall apply to diaphragm cooled centrifugal compressors.

(b) Equipment and Piping

1 Water flow sight glasses are not required on the diaphragm chamber water outlet or inlet. Gas leakage to the water circuit shall be detected by monitoring standpipe gas. Location of leaks within the compressor is normally determined from water dye marks.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA2w (Cont'd)

2 Water piping shall return from the oxygen compressor to an open standpipe to permit escape of oxygen gas in case of leakage within compressor. Standpipe design shall provide for the following:

a Separation of oxygen bubbles by flow from inlet to outlet basins divided by a weir.

b Tranquil basin for water pump suction.

c Continuous water change to prevent freezing.

d Makeup water connection.

e Port for addition of chemicals.

f Water level sight glass.

3 In freezing climates, steam piping shall be permanently connected through a valve to each leg of the water inlet manifold for use in preventing ice formation in diaphragm chambers during winter shutdown periods.

4 Low point drains shall be provided to drain each diaphragm. These drains will be utilized to promote steam circulation during winter shutdown periods.

Note: Diaphragm compartments above the case split line cannot be drained by gravity nor can they be blown dry easily. Therefore, steam is essential to prevent freezing in these compartments.

x. Cleanliness of Oxygen Equipment and Piping

All oxygen equipment, oxygen piping and nitrogen purge piping for oxygen equipment shall be cleaned to achieve the class AA level defined by QCL 101 F. Purchase specifications and construction specifications shall include this requirement as well as suitable requirements for maintaining cleanliness, until equipment or piping is ready for operation, i.e. gasketed blind flanges, dry gas fill, dry gas purge, etc.

3. Instrumentation

The following instrumentation shall be provided for the oxygen compressing system. See table I for control valve action during normal or emergency shutdown and during air or electrical failure.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA3 (Cont'd)

a. Refer to standard 578.60.1 for pressure control, vent, recycle, and relief valve materials.

b. Pressure controlling vent valve (PIC-21-V_2) shall be provided on all plants upstream of the compressor suction throttle valve to vent excess oxygen product and maintain compressor suction pressure at the desired value. The valve and vent piping shall be sized to pass full product flow at 3 psig or greater depending on expected line pressure at full oxygen flow. Where fine control is necessary as for a pressure control system without product backup, a smaller trim valve (PIC-21-V_1) may also be provided. In this situation, the trim valve shall be equipped with a limit switch and alarm (FAL-18) to warn the operator of a low vent rate.

c. A low pressure switch (PSL-80) and alarm (PAL-80) shall be provided upstream of the compressor suction throttle valve to alert the operator in case of abnormally low suction pressure and to recycle the compressor if the decline continues to subatmospheric level. The low pressure switch shall be located remote from the compressor suction piping to prevent actuation by mechanical vibration caused by switch valve operation. The connection from switch to suction piping shall be by flexible tubing.

d. A low temperature switch and alarm shall be provided on the suction piping of any compressor taking suction from a possible cold source. Setting shall be based on area climate but in no case shall it be set below -5°F.

e. When the suction piping downstream of the throttle valve or the compressor suction side has a maximum allowable working pressure (MAWP) less than the compressor discharge pressure, a relief device shall be provided between the suction throttle valve and the compressor to protect the weakest component (usually the bellows) from overpressure. The overpressure can occur from pressure surges during recycle or during compressor shutdown if the discharge check valve hangs open while the discharge block valve is open (by operator error or emergency shutdown).

When a relief device is required and the MAWP of the suction piping and the compressor case is 55 psig or more above the maximum suction pressure, the relief device shall be a rupture disc (SD34). The disc shall have a burst pressure at 72°F equal to the MAWP of the weakest suction side component. It shall be sized for a flow at this pressure equal to the sonic flow through the discharge check valve in a 5% open condition or to relieve 40% of the maximum flow through the recycle

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA3e (Cont'd)

valve, whichever is greater.

When a relief device is required and the suction piping or the compressor case MAWP is below the minimum values specified above for a rupture disc, a safety valve shall be utilized in place of the rupture disc. Set pressure shall equal the MAWP of the weakest suction side component. The flow rate shall be equal to the sonic flow through the discharge check valve in a 5% open condition or to relieve 40% of the maximum flow through the recycle valve, whichever is greater.

f. The suction throttle valve (PIC-22-V) shall be a tight shut-off butterfly type utilizing a Teflon, Kel-F or Viton-A seat. The valve shall be capable of closing in less than 3 seconds from the full open position.

g. Temperature Indicators/Controls

(1) All thermocouples, thermometers and temperature bulbs located in pressurized piping, except as required by paragraph (2) below, shall have separate wells consistent with the particular piping specifications.

Wells shall be immersed 1/3 to 1/2 of pipe diameter up to a maximum well length of 6 inches. Additionally, the wells for bimetallic thermometers shall have a minimum immersion length of 4 inches for gas streams and 2 inches for liquid streams. Wells shall conform to standard 532.3.

In addition to the special case for paragraph (2) below, temperature indicators may also be installed without wells in piping operating at atmospheric pressure, provided they can be removed and replaced without interrupting plant operation.

(2) A high temperature indicator-switch and alarm shall be provided on each stage discharge upstream of the cooler. Maximum permissible setting shall be:

Alarm: 340°F
Compressor Shutdown: 350°F

Each producing facility shall establish a lower setting when experience with operating temperatures indicate this is possible. Settings shall be:

Alarm: 10°F above maximum normal summertime operating temperature.
Shutdown: 20°F above maximum normal summertime operating temperature.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA3g (2) (Cont'd)

Each temperature point shall utilize a dual sensing thermocouple as indicated below with one set of leads connected to a manual selector switch and potentiometer indicator mounted in or adjacent to the oxygen compressor instrument panel. The other set of leads shall be connected to an alarm and compressor shutdown circuit through a thermocouple switch as indicated below. The thermocouple probe shall be installed without a well. The probe shall extend into the fluid stream 1/2 inch ± 1/8 inch) past the pipe inner wall or past the inner end of a pipe half coupling, if used.

(a) Dual Sensing Thermocouple

1. Probe outside diameter:	1/4 inch
2. Sheath material:	304 stainless steel
3. Calibration:	Copper - Constantan
4. Insertion Length 'U':	1 1/2 inch*
5. Part No.:	Thermo-Electric No. 11484 with dual element, or equal

(b) Thermocouple Switch

1. No. switches:	Two
2. Type:	SPDT
3. Range:	0-400°F
4. Calibrated Adjustment dial:	Required
5. Relay:	Normal energize High temperature trip - de-energize
6. Model:	Rochester Instrument No. ET-205, or equal

*Max. acceptable length for line velocity to 200 ft/sec. and pressure to 1500 psig.

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IVA3g (Cont'd)

(3) A temperature indicator shall be provided in the process stream at each intercooler outlet, aftercooler outlet, and oil return piping* from each bearing or at each bearing. Temperature points inside the personnel protective shield, excepting water temperatures, shall utilize copper-constantan type thermocouples connected to a manual selector switch and potentiometer indicator mounted in or adjacent to the oxygen compressor instrument panel. See paragraph A3t (1) (a), pg. 16, for water temperature indicators.

(4) A high oil temperature indicator-switch (TISH-41), bulb type, shall be installed in the oil return header* from the bearings to the oil sump. The switch shall be connected to the alarm on the oxygen compressor instrument panel. The intent of this requirement is to warn the operator of excessive oil temperature due primarily to insufficient water flow.

(5) The motor winding temperature indicator (TI-3) shall be located on the main instrument panel. A switch shall automatically shut down the compressor on excessive temperature.

(6) The motor cooling air temperature switch (TSH-72) shall actuate an alarm located on the oxygen compressor panel in case of excessive temperature.

h. An antisurge control system shall be provided to continuously monitor and automatically control the compressor under any given pressure and flow conditions at a point 5% (used for control tolerance) greater than the actual machine surge curve.

Antisurge control shall in all cases be effected by bypass to suction between the suction throttle valve and the compressor. Bypass valve shall be sized to handle 120 percent of rated compressor flow at design discharge pressure after allowing for pressure drop in the piping to the valve. The bypass valve (FRC-10-V) shall be capable of opening fully in less than 2 seconds from the closed position.

*Temperature indicators assembled in oil piping shall be located in a horizontal run and in a position to be at least 50 percent submerged considering the piping to run half full. Due to the low fluid velocity, the indicator length may exceed the normal 6-inch limit if necessary to achieve the required submersion.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA3h (Cont'd)

"Surge" shall be controlled by using a "Mass Flow" and "Discharge Pressure" system. Mass flow shall be monitored on the compressor discharge, using a "Low Loss Flow Tube" (FRC-10-E) (see note), B.I.F. DFTW-3 or equal with 316 S.S. body and throat and a Hagan mass flowmeter RB-3002-R80-PC-EC-HT or equal. The discharge pressure signal shall be measured and transmitted by a "Bristol" or equal pressure transmitter. The surge pressure and flow transmitters shall be used for compressor bypass valve control. The flow transmitter only shall be used for suction valve control on mass flow systems. Suction valve control may be operated from suction or discharge pressure for pressure control systems. The transmitters may also be used for main control room monitoring.

Surge control components shall be:

	HAGAN NO.
Pressure Computer	174600-1030808
Antisurge Controller	174600-1030808
Needle Valve	12820-L
Volume Chamber	474549-002
Antisurge Controller Auto-Manual Station	450603-1-L, 0-30 psi inverse
Pressure Gauges	(4) - 0-60 psi, 2 in. dial
	(1) - 0-30 psi, 2 in. dial

Note: Since the flow tube is also utilized in determining compressor performance data, it shall be water calibrated to establish actual coefficients of discharge and shall be installed in accordance with Design Engineering Standard 533.1 utilizing straightening vanes (FX-35) conforming to AGA Gas Measurement Committee Report Number 3-1969. Water calibration is not required if the oxygen compressor is an exact duplicate of proven capacity.

i. An inventory dump valve (ECV-19-V) is required downstream of the aftercooler and upstream of the product line check valve. It shall be a ball type sized to dump compressor system inventory to a pressure below 15 psig in 10 seconds. The valve shall fully open in less than 2 seconds from the closed position.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA3 (Cont'd)

j. Two vent valves shall be provided adjacent to the manual block valve in the oxygen product line.

(1) The upstream vent valve shall be a 1/2 inch, bronze, globe type for venting nitrogen prior to compressor startup. Control shall be manual.

(2) The downstream vent valve shall be 1/2 inch to 2 inch as required for rapid system purge (5 minutes) when starting or stopping flow to the customer. It shall be a bronze, globe type. Control is dependent on operating pressure level.

(a) Below 600 psig - Use manual valve.

(b) Above 600 psig - Use hand indicator control valve (HIC-15-V) with control from oxygen compressor instrument panel.

k. If an automatic pressure control vent system is required to maintain pressure in the product delivery line, it shall consist of a pressure control valve (PIC-60-V) with the controller mounted on the main instrument panel, and a vent silencer in accordance with standard 558.5.2.

l. Paymeters shall consist of a flow element (FR-21-E) and an indicator recorder (FR-21-R). Installation shall be in accordance with Design Engineering Standard 533.1 utilizing straightening vanes (FX-36) conforming to AGA Gas Measurement Committee Report Number 3-1969.

m. An automatic product line shutoff valve (ECV-47-V) is required to stop flow in case of line rupture. The valve shall be actuated by a switch (FR-21-SH) set at desired maximum flow rate (approximately 200% of normal compressor flow) through an element (FR-21-E). An alarm (FAL-26) shall sound on the main instrument panel when ECV-47-V closes.

n. Equipment shall be provided as follows for monitoring radial vibration, axial vibration, and axial position of each compressor rotor shaft and of the high-speed pinion. This equipment shall be connected to the oxygen compressor instrument panel alarm (VAH-21). A switch (VSH-21) shall shut down the oxygen compressor in case of excessive vibration at any point normally connected for continuous monitoring.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA3n (Cont'd)

Location	Probe No.	Proximeter	Coaxial Cable	Reading
Compressor Outboard End	1	Req'd	Req'd	Axial Position
				Axial Vibration
	2	Req'd	Req'd	Vertical Vibration
	3	None	Req'd	Horizontal Vibration
Compressor Inboard End	4	Req'd	Req'd	Vertical Vibration
Compressor Inboard End	5	None	Req'd	Horizontal Vibration
High-Speed Pinion	6*	*Req'd	*Req'd	Vertical Vibration
	7*	*Req'd	*Req'd	Axial Position
				Axial Vibration

Each probe shall be wired with electrically compatible coaxial cable to extend into the proximeter box, which shall be located outside the personnel protective shield. Only those probes listed with proximeters will normally be connected for continuous monitoring. Monitors shall be located in the oxygen compressor instrument panel on all future plants. Monitors may be located adjacent to the instrument panel on current plants.

Instrumentation for each additional compressor in a train shall duplicate the above.

Continuously monitored vibration points shall be set for alarm and shutdown at initial startup and after every major overhaul as follows:

Maximum normal vibration** + 0.5 mil: Alarm

Maximum normal vibration + 1.5 mil: Automatic shutdown.

Note: Manual shutdown is required at 1.0 mil above maximum normal vibration.

The vibration shutdown switch shall be provided with a time delay relay to bypass this circuit until the compressor is up to operating speed.

*If gear arrangement permits.
**As experienced while operating with oxygen at normal line pressures.

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IVA3n (Cont'd)

All vibration instrumentation shall be Bently-Nevada. Although various applications may require different components, the following "standard" equipment shall be utilized where practical.

Probe:	#306-L-30
Proximeter:	#3120
Extension Cable:	15 feet
Monitor, Radial:	#1RV (Scale = 0-5 mils)
Monitor, Axial:	#1CAVAP (Movement Scale = 25-0-25 mils) (Vibration Scale = 0-5 mils)
Power Unit:	#S18R

Wiring from the probe to the monitor shall be contained in electrical conduit in general accordance with the following:

(1) The probe and its pigtail shall be installed by the compressor manufacturer in accordance with standard 551.3.1 to provide an oil tight mechanical seal between the compressor case and an electrical connection box.

(2) An extension cable shall be run in Sealtite from the connection box on the compressor case to the proximeter box.

(3) Wiring from the proximeter box to the monitor shall be in hard conduit.

o. Water-cooled motors shall be protected against internal water leakage from overhead coolers by a liquid-level switch (LSH-23) connected to an alarm on the oxygen compressor panel or by a bottom drain continuously open to atmosphere.

p. A permissive start switch, auxiliary pump start switch, and low oil pressure switches shall be connected to the oil feed line between the oil filters and the compressor. Settings shall be at progressively decreasing pressures in the order indicated below.

(1) Permissive start at normal minimum operating pressure.

(2) Alarm.

(3) Auxiliary pump start.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA3p (Cont'd)

(4) Compressor shutdown at minimum pressure recommended by the compressor manufacturer.

The alarm shall be located on the oxygen compressor panel.

q. All process and seal gas tubing from the compressor to the compressor assembly bulkheads shall be stainless steel. Tubing from the bulkhead to the instrument panel shall be stainless steel (or copper if mechanically protected). Tubing within the panel shall be copper.

r. Instrument piping shall be remote from oil piping and located to prevent contamination in case of an oil leak.

s. Two emergency stop switches shall be provided for the oxygen compressor.

(1) A large red button on the oxygen compressor instrument panel.

(2) A knife switch in the main control room.

Note: These switches shall be prominently labeled and readily accessible to operating personnel. Therefore, they shall be located within 6 feet of the operating platform or floor below the switch.

They shall also be located to prevent unintentional actuation, therefore other doors shall not open within 6 inches of these switches.

t. Cooling Water Instruments

(1) Open System

(a) A temperature indicator shall be provided in the water outlet stream from each intercooler, aftercooler, oil cooler, motor cooler, closed system water cooler, and circulating pump.

Intercooler and aftercooler temperature points will normally be located inside the personnel protective shield. These temperatures may be indicated by local thermometers or by copper-constantan thermocouples, with a readout at the oxygen compressor instrument panel, as economic considerations dictate.

Remaining temperature points shall utilize local thermometers located outside the shield.

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IVA3t(1) (Cont'd)

(b) A locally mounted pressure gauge shall be provided to indicate water pressure in the outlet header from the circulating water pumps.

(c) A pressure switch shall be connected to actuate an alarm located on the main instrument panel, in case of abnormally low water pressure in the water pump outlet header.

(d) Red running lights shall be provided for the following equipment:

1 Cooling tower fans

a Lights to be located on the control station at base of the tower.

b Lights to be located on the main instrument control panel.

Note: A separate light shall be used to indicate operation at each speed.

2 Water pumps

Operation of each pump shall be indicated by a separate light on the main instrument panel.

(e) Start-stop switches for fans and pumps shall be located as follows:

1 Fans

In control station at the base of the tower.

2 Pumps

a In control station at the base of the tower.

b On the main control panel.

(f) Loss of cooling tower fan operation shall be indicated by an alarm located on main control panel.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVA3t (Cont'd)

(2) Closed System

(a) A temperature indicator shall be provided in the water outlet headers from diaphragm cooled compressors and from the water cooler. Temperature points will normally be outside the personnel shield and shall be locally mounted thermometers.

(b) A locally mounted pressure gauge shall be provided to indicate water pressure in the outlet header from the water pumps.

(c) Pressure switches shall be connected to the outlet header from the water pump to perform the following functions at progressively decreasing pressures in the order indicated below:

1 Actuate the alarm on the main instrument panel.

2 Start the standby water pump, when provided.

3 Shutdown the oxygen compressor after a preset time delay.

4 Parallel compressor arrangements, utilizing a common closed cooling system, shall also include a flow control switch in the piping to each compressor. The switch shall be connected to permit starting of an oxygen compressor motor only after flow is established to that compressor and shall shut down the compressor on loss of flow after a preset time delay.

(d) Red running lights shall be provided to indicate operation of each water pump utilized. The lights shall be located on one oxygen compressor instrument panel.

(e) A start-stop switch for the water pump shall be located on the oxygen compressor instrument panel near the water pump running lights.

u. Seal Gas Instruments

Instrumentation for seal gas systems will vary for different compressors and facility capabilities. The following requirements are general and must be adjusted in detail to suit each situation:

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IVA3u (Cont'd)

(1) Pressure gauges shall be provided to indicate seal gas pressure at each shaft seal port. Gauges shall be mounted on oxygen compressor panel.

(2) Pressure switches shall be provided to alarm and shut down the compressor when manufacturer's limits are exceeded for the following conditions.

(a) Shaft seals (refer to figure 1 for port locations)

1 Pressure at injection port too low (port C).

2 Pressure at bearing end is too low (port E).

3 Pressure at impeller end is too high (port B).

4 Differential pressure between ports B and C is too low.

(b) Seal gas backup system pressure is too low (alarm only).

(3) Pressure reducing valves shall be provided as necessary in the main seal gas piping and in the backup system piping to achieve seal gas pressures recommended by the compressor manufacturer.

(4) Locally mounted gauges shall be provided to indicate seal gas pressure after each pressure control valve required by paragraph (3), above. These gauges shall be located adjacent to the valves.

(5) A pressure gauge shall be mounted on the oxygen compressor panel to indicate seal gas pressure after the filter and before the pressure reducing valve on the main seal gas line to the compressor.

v. Rotor Shift Instruments

Instrumentation for rotor shift systems will vary for different compressors. The following requirements apply to compressors normally utilized and must be adjusted to suit particular equipment:

(1) Pressure switches shall be provided to alarm and shut down the compressor when rotor shift system pressure exceeds manufacturer's recommendations.

(2) A locally mounted pressure gauge shall be provided to indicate pressure at the switches.

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IVA3v (Cont'd)

(3) A pressure control valve shall be provided to obtain the manufacturer's recommended pressure to the rotor shift mechanism.

w. Instruments exposed to oxygen shall meet the cleanliness level established by QCL-116F.

4. Location

a. The oxygen compressor shall be located to minimize exposure to operating personnel and to associated equipment. See Design Engineering Standards 570.6 and 546.1 for location of the oxygen compressor in plant layout and for location of personnel shields, instrument panel, valves, etc. respectively.

b. Except where specifically exempted herein, all instruments and controls for the oxygen compressor shall be located outside the personnel protective shield if adjustments or observations are required during oxygen compression. Except where practical limitations prohibit, all indicating instruments and remote controls shall be mounted on a panel. The panel shall be positioned on the normal line of approach to the compressor area in accordance with the objectives of Design Engineering Standard 546.1.

c. Lube oil lines, electrical lines and oxygen lines shall be run along separate routes and shall utilize separate troughs. Oil piping shall be positioned to prevent oil from dripping on oxygen lines, oxygen instrument runs, or electrical conduit and equipment.

B. Reciprocating Compressors

Design criteria established for centrifugal compressors shall apply to reciprocating compressors, except that seal gas, surge control, and proximity vibration systems do not apply and the following changes and additions are required:

1. System Equipment and Piping

a. Compressor - See Design Engineering Standards 552.2.1.

b. The 2-inch vent valves required for carbon dioxide and nitrogen mixture on centrifugal compressors are not required on reciprocating units.

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IV81 (Cont'd)

c. Oil travel along piston rods and oil vapor in the distance piece area shall be prevented by the following design requirements:

(1) Single distance piece machines (Sulzer).

(a) Single distance piece design is permitted only in a vertical plane.

(b) Distance piece side covers shall be removed.

(c) An oil flinger shall be sealed to piston rod within each distance piece to prevent migration of oil along the rod.

(d) Ejector equipment shall be provided to obtain a slight vacuum (1 to 3 inches water) on crankcase.

The standard ejector shall be a Schuttle & Koerting Co. (or equal) Model 217, style 60 nozzle, all brass construction, 3/8" FNPT pressure connection and 1/2" vacuum connection. A block valve and a pressure regulating valve shall be provided on the air inlet piping to the ejector. These valves shall be located outside the personnel shield.

(2) Double distance piece machines.

(a) Side covers shall be installed on each cylinder end distance piece. Side covers shall be hinged at top only to prevent over-pressurization of distance pieces.

(b) Cylinder end distance piece chambers shall be purged continuously with nitrogen and vented individually outside personnel barrier to permit periodic sampling for oxygen.

(c) Side covers shall be removed from each crankcase end distance piece.

(d) Crankcase end distance piece chambers shall be provided with low point drains piped outside personnel shield to a common collection pot. Manifolding is permitted.

(e) An oil flinger shall be sealed to piston rod within each distance piece (two flingers per rod) to prevent migration of oil along the rod.

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IVB1c(2) (Cont'd)

(f) Ejector equipment, in accordance with paragraph (1) (d) above, shall be provided to obtain a slight vacuum (1 to 3 inches water) on the crankcase.

d. Black lights shall be provided for inspection of the piston rods on single distance piece compressors. The black lights (long wave ultraviolet lights) shall be permanently positioned to shine on the piston rods and cylinder end of the distance piece chamber from both sides of the compressor. Each black light may cover one or more piston rods, provided the rods are located within the length of the light. Each light shall be located within 3 feet of the rods and at the lower side of the distance piece chamber. The light housing shall be positioned to shield direct light rays from personnel viewing the piston rods from outside the personnel shield. A separate switch shall be provided to actuate the lights on each side of the compressor independently from the other side. Switches shall be located outside the protective barrier.

The black lights shall be either fluorescent type or mercury* floodlight type with either a one-lamp or two-lamp fixture, procured to the following specifications or equal:

(1) Fluorescent

(a) Fixture, 54 inch long, vapor tight, two-lamp with angle mounting brackets, plastic cover and low temperature ballast, Thomas Industries Benjamin Products catalog FV-4324-4.

(b) Lamps, fluorescent black light, 48 inches long, medium bipin base, 40 watt, 1½ inch bulb diameter, blue type integral filter, G.E. Co. catalog F40BLB.

(2) Mercury*

(a) Fixture, adjustable surface mounted, 90% power factor ballast, long enclosed bullet, 175 watt, complete with ultraviolet lens, Stonco catalog 48-UV and snap-on lens holder, Stonco catalog 47. One-lamp fixture, Stonco S-68575 MM or two-lamp fixture, Stonco S-68576 MM.

(b) Lamp, 175 watt, mercury, reflector flood, R-40 bulb, G.E. Co. catalog H.75RFL 39-22.

*Requires several minutes warm-up time.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVB1 (Cont'd)

e. Piston Rod Packing Leakoff Piping:

(1) Packing leakoff shall normally be piped to the compressor suction upstream of the suction strainer. Packing leakoff piping from multistage compressors shall be manifolded for a single return to suction. The leakoff may be vented to atmosphere when the rate is economically acceptable.

Leakoff piping shall be silver brazed copper tube or welded stainless steel. This piping shall conform to the rules for oxygen piping cleanliness. Therefore, leakoff piping connected to suction piping must be flanged or connected with unions at extreme ends to permit cleaning after fabrication.

(2) Vent Piping

(a) Carbon Packing

When packing leakoff piping is connected to compressor suction, a check valve and ball type vent valve shall be provided in the leakoff piping to permit unrestricted leakoff venting to the atmosphere during each start-up period on nitrogen. These valves shall be located as close to the manifold as practical. Piping from each leakoff point to the vent valve shall contain no low points. The vent valve shall be connected to the straight-though leg of a tee and the side leg shall run vertically upward for connection to the check valve before returning to compressor suction.

(b) Teflon or Bronze Packing

The atmosphere vent arrangement required for carbon packing, paragraph (a) above, is not required for teflon or bronze packing.

f. Interstage unloading shall be by manual valves operable from inside the personnel protective shield. Therefore, these valves are for adjustment only while operating the oxygen compressor on nitrogen.

g. Cooling Water Systems

(1) Open System

Requirements are the same as those for the centrifugal compressor.

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OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVBlg (Cont'd).

(2) Closed System

(a) This system shall conform to the requirements of a closed system for centrifugal compressors and shall apply to the following circuits:

1 Cylinder jackets.

2 Crossheads.

3 Guide bearings.

(b) Equipment and Piping

1 Water flow sight glasses are required on the outlet from each circuit per (a), above. They shall be located outside the personnel shield.

2 A globe type flow control valve shall be located in the outlet line from each circuit per (a), above. These valves shall be located outside the personnel shield.

3 A 1/2-inch drain valve shall be installed in each circuit cooled to permit draining for maintenance purposes.

2. Instrumentation

a. Refer to standard 578.60.1 for pressure control, vent, recycle and relief valve materials.

b. Final discharge pressure control of both single and parallel compressor arrangements shall be accomplished through a pressure indicating control valve, with return to suction. The control shall be mounted on the compressor instrument panel.

c. Final stage unloading of parallel compressor arrangements shall utilize individual hand indicator control valves, with return to suction. The control shall be mounted on the oxygen compressor panel.

d. Inventory dump valves are required following the intercoolers of each compression stage in addition to the normal requirement following the aftercooler. The valves shall be sized to dump the inventory contained between inlet valve of the preceding cylinder to the inlet valve of the next stage cylinder to a pressure below 5 psig in 3 seconds.

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IVB2 (Cont'd)

e. The bypass control valve (FRC-10-V) shall automatically close under all modes of shutdown (normal, malfunction, panic, air failure or electrical failure).

f. A relief valve is required between the suction throttle valve and the compressor if the suction side maximum allowable working pressure (MAWP) is less than the compressor first stage discharge relief valve setting. Set pressure shall equal the MAWP of the weakest suction side component.

The flow rate shall equal the excess flow of the bypass control valve at design discharge pressure as compared to the compressor flow. This sizing is for protection against a bypass control valve hangup or operator error.

Example: If the bypass control valve actual size will handle 123% of the compressor flow, the relief valve shall be sized to handle a minimum of 23% of the compressor flow.

g. Interstage pressure gauges shall be provided on the oxygen compressor instrument panel to monitor each stage discharge pressure. Pressure taps shall be located before each stage cooler.

h. Each valve cover temperature shall be monitored by copper-constantan thermocouples and read out by potentiometer mounted at or in the compressor instrument panel.

i. Compressors with horizontal cylinders shall utilize piston rod detectors for protection against piston rider ring wear. The detectors shall utilize a copper housing containing a low melting temperature eutectic plug (220°F melting point), connected to low-pressure instrument air. Rubbing action resulting from rod displacement shall melt the eutectic plug, releasing pressure and actuating the pressure switch for compressor shutdown.

j. Seismic type vibration switches shall be provided to shut down the compressor when frame vibration amplitude increases to twice the value at the new condition as accepted by Machinery Engineering. A minimum of one switch per two crank throws is required. Each switch shall be mounted directly on the compressor frame in line with the main bearing between, or adjacent to, the two throws. Each switch shall be wired to light a yellow light, which will indicate the switch that has shut down the compressor. The light shall be maintained until the switch is reset. The switch shall be Robertshaw Fulton Model 366 or equal with manual reset.

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Date 7/19/71

OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

IVB2 (Cont'd)

k. Locally mounted thermometers shall be installed to indicate the outlet temperature of each circuit in a closed circuit cooling system. These thermometers shall be located outside the personnel shield and shall be adjacent to the flow control valves for these circuits.

l. An auxiliary oil pump automatic start switch is not required since the compressor stops very rapidly after the shutdown circuit is actuated.

m. A compound vacuum gauge shall be provided on the suction line to the crankcase ejector nozzle. The gauge shall be located outside the personnel barrier adjacent to the regulating valve on the pressure inlet line to the nozzle.

The gauge shall be Robertshaw model 313 BD or equal conforming to Design Engineering Standard 531.2, G-602A except the range shall be 10 inches water - 0-10 inches water.

n. A high oil temperature indicator switch, bulb type, shall be installed in oil supply line from the oil cooler to the frame. Well for bulb shall be located in horizontal piping and in a position to be at least 40% submerged considering the piping to run half full. The switch shall be connected to an alarm on the oxygen compressor panel. The intent of this requirement is to warn the operator of excessive oil temperature due primarily to insufficient water flow.

o. A low pressure switch shall be located between the compressor and suction screen to alarm and to shut down the compressor. This arrangement is required to alert the operator in case of abnormally low suction pressure and to shut down the compressor if the decline continues to an unacceptable level. A lock type switch shall be installed on the oxygen compressor instrument panel to bypass the low pressure switch during start-up on nitrogen. An amber light shall also be mounted on the panel to indicate use of the bypass circuit.

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Date 7/19/71

OXYGEN COMPRESSOR SYSTEM — APCI OPERATED

TABLE I

Valve Operation Mode

Valve	Shutdown		Failure*
	Normal	Malfunction or Panic	
PIC-21-V_1	Throttling to maintain pressure	Throttling to maintain pressure	Closes
PIC-21-V_2	Throttling to maintain pressure	Throttling to maintain pressure	Closes
PIC-22-V	Closes	Closes	Closes
FRC-10-V	Opens	Opens	Opens
ECV-19-V	Opens	Opens	Opens
ECV-47-V	Remains open	Closes on excessive flow only	Closes
PIC-60-V	Throttling to maintain pressure	Throttling to maintain pressure	Closes

*Air or electrical failure.

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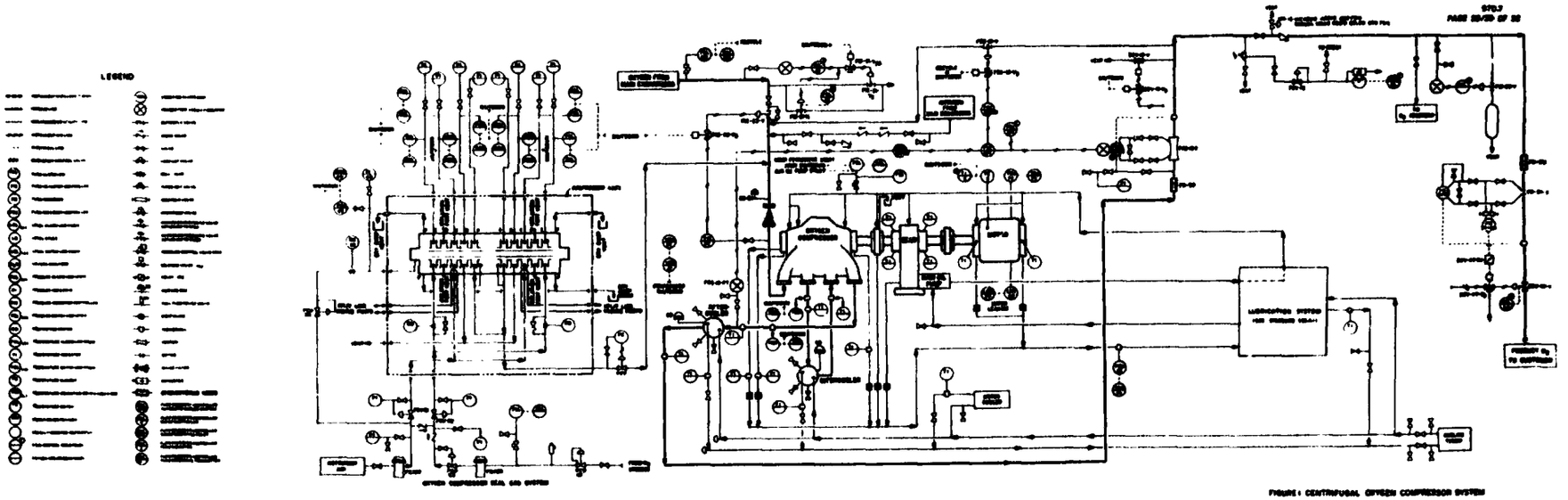


FIGURE 1 CENTRIFUGAL OXYGEN COMPRESSOR SYSTEM

7-0-11

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OXYGEN COMPRESSOR SYSTEM

PRECEDING PAGE BLANK NOT FILMED

APCI OPERATED

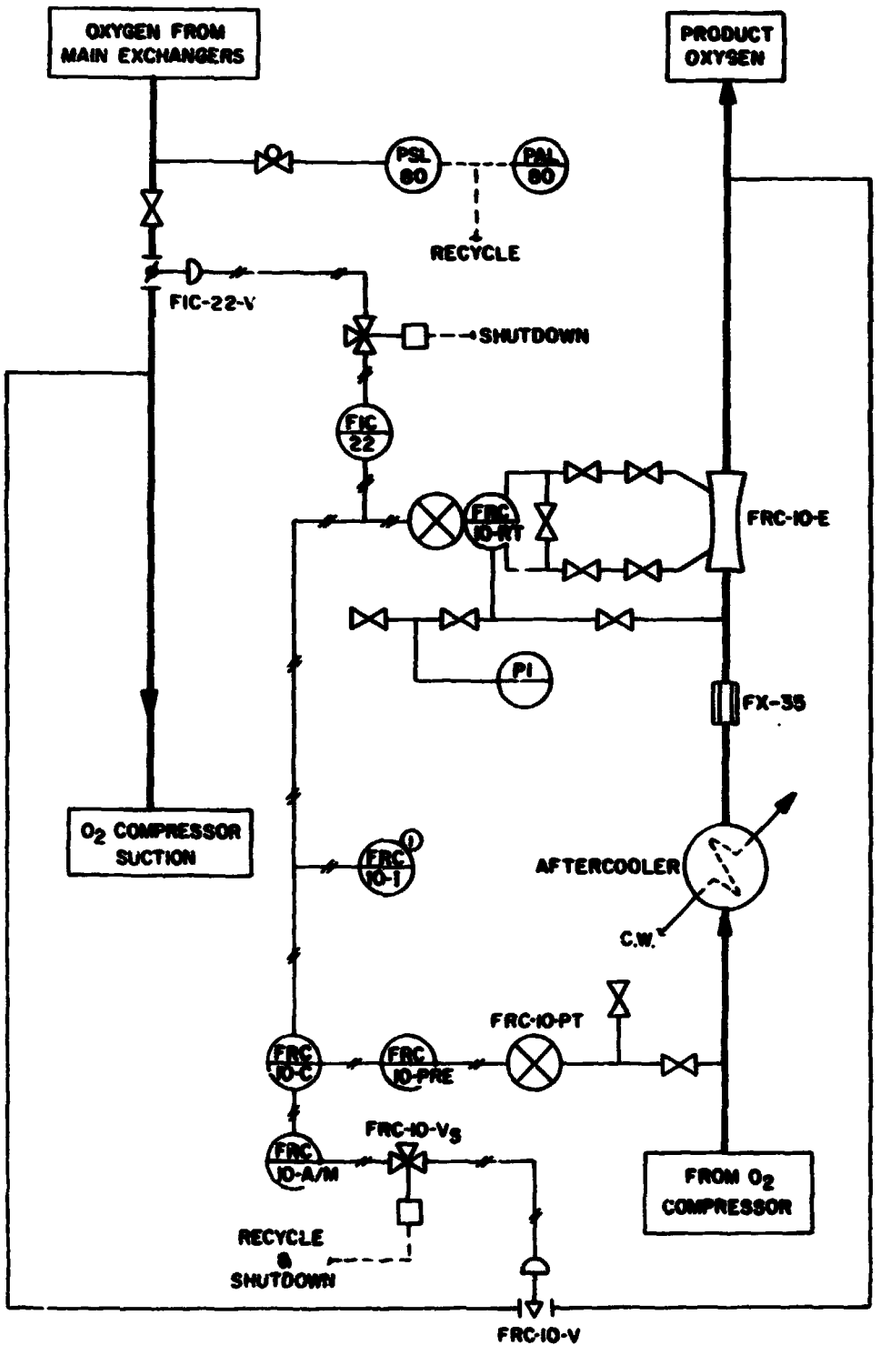


Figure 2. Mass Flow Control System.

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CONE TO BE STAINLESS STEEL TYP. 304 AND BUTT WELDED WITH TUNGSTEN-INERT GAS WELDING PROCESS. THE CONE SHALL HAVE A MINIMUM OPEN AREA OF 40% USING HOLE DIA. (d) ON A TRIANGULAR PITCH (X). SCREEN ON OUTSIDE TO BE MONEL, 100 X 100 MESH, .0045 WIRE, .0055 OPENING, 30.3% OPEN AREA. SPOT WELD OR SILVER BRAZE SCREEN TO CONE AT LONG SEAM AND AT CONE TO FLANGE JUNCTURE (SPOT WELDS TO BE AS CLOSE AS POSSIBLE APPROXIMATING A CONTINUOUS WELD).

CLEAN FOR CLASS AA OXYGEN SERVICE IN ACCORDANCE WITH APCI QCL 116F.

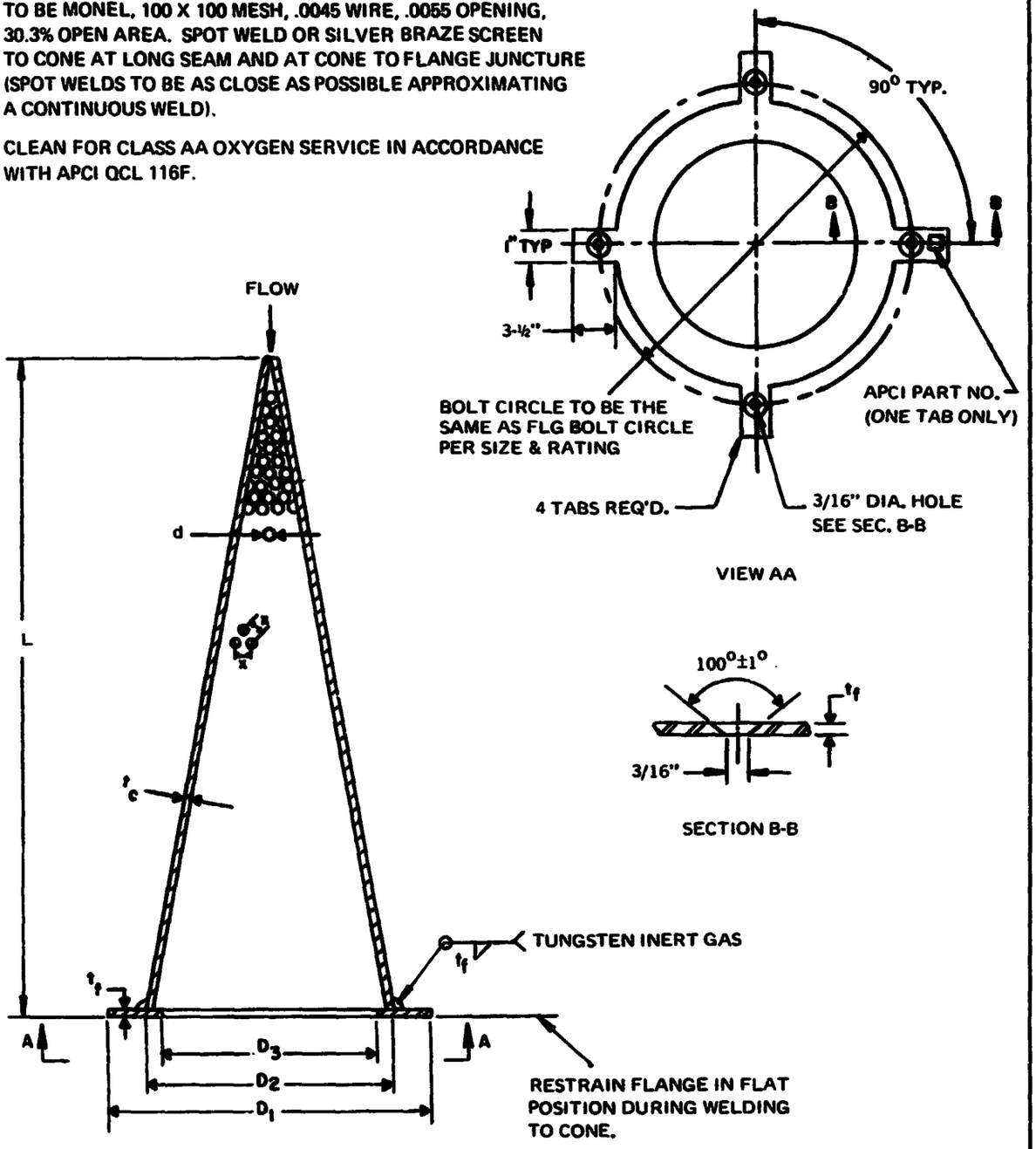


Fig. 3 Conical Strainers for Compressor Suction Lines (Sheet 1 of 2)

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PART NO. & DIMENSIONS

APCI Part No. (Dwg. 92898D)	Pipe Size & Flg. Rating	L	D_1	D_2	D_3	t_c	t_f	d	x	Approximate Buckling Pressure Difference
– 4	4"-150#		6 5/8"			14 GA.	14 GA.			
– 4A	4"-300#	11 1/2"	6 7/8"	3 5/8"	3 3/8"	(.0747)	(.0747)	1/8"	3/16"	400 PSI
– 4B	4"-600#		7 3/8"							
– 6	6"-150#		8 1/2"			14 GA.	14 GA.			
– 6A	6"-300#	17"	9 5/8"	5 1/2"	5 1/4"	(.0747)	(.0747)	1/8"	3/16"	250 PSI
– 6B	6"-600#		10 1/4"							
– 8	8"-150#		10 3/4"			14 GA.	14 GA.			
– 8A	8"-300#	23"	11 7/8"	7 1/8"	6 7/8"	(.0747)	(.0747)	1/8"	3/16"	140 PSI
– 8B	8"-600#		12 3/8"							
–10	10"-150#		13 1/8"			14 GA.	14 GA.			
–10A	10"-300#	27"	14"	9"	8 3/4"	(.0747)	(.0747)	1/8"	3/16"	80 PSI
–10B	10"-600#		15 1/2"							
–12	12"-150#		15 7/8"			14 GA.	14 GA.			
–12A	12"-300#	32 1/2"	16 3/8"	10 7/8"	10 5/8"	(.0747)	(.0747)	1/8"	3/16"	60 PSI
–12B	12"-600#		17 3/4"							
–14	14"-150#		17 1/2"			7 GA	11 GA.			
–14A	14"-300#	35"	18 7/8"	12 5/8"	12 3/16"	(.1793)	(.1196)	1/4"	3/8"	250 PSI
–14B	14"-600#		19 1/8"							
–16	16"-150#		20"			7 GA.	11 GA.			
–16A	16"-300#	39"	21"	14 1/2"	14 1/16"	(.1793)	(.1196)	1/4"	3/8"	210 PSI
–16B	16"-600#		22"							
–18	18"-150#		21 3/8"			7 GA.	11 GA.			
–18A	18"-300#	44"	23 1/4"	16 3/8"	15 15/16"	(.1793)	(.1196)	1/4"	3/8"	175 PSI
–18B	18"-600#		23 7/8"							
–20	20"-150#		23 5/8"			7 GA.	11 GA.			
–20A	20"-300#	49"	25 1/2"	18 3/8"	17 15/16"	(.1793)	(.1196)	1/4"	3/8"	140 PSI
–20B	20"-600#		26 5/8"							
–24	24"-150#		28"			7 GA.	11 GA.			
–24A	24"-300#	58"	30 1/4"	22 3/8"	21 15/16"	(.1793)	(.1196)	1/4"	3/8"	70 PSI
–24B	24"-600#		30 7/8"							
–30	30"-150#		34 1/2"			7/32"	11 GA.			
–30A	30"-300#	70"	37 1/4"	28 3/8"	27 7/8"	(.2188)	(.1196)	3/8"	9/16"	70 PSI
–30B	30"-600#		38"							
–36	36"-150#		41"			7/32"	11 GA.			
–36A	36"-300#	88"	43 3/4"	34 3/8"	33 7/8"	(.2188)	(.1196)	3/8"	9/16"	45 PSI
–36B	36"-600#		44 1/4"							

Fig. 3 Conical Strainers for Compressor Suction Lines (Sheet 2 of 2)

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Date 7/19/71

AIR PRODUCTS AND CHEMICALS, INC.

Put It In Writing

DATE April 13, 1964

TO J. J. Mittleman

SUBJECT Specialty Gas Gauge Failure

FROM W. W. Schmoyer

cc: R. D. Barclay
J. P. Barker
W. H. Eggers
A. L. Hatley
M. H. Hubbs
H. H. Master
G. Phillips
L. P. Pool

Attached is the report on an oxygen pressure gauge failure which occurred March 23, 1964 at the Specialty Gas Facility at Plant #1, Emmaus, Pa.

An employee received a bruise on the left hand, was treated, and returned to duty.

The reaction took place where the bourdon tube is joined to the inlet connection of the gauge and caused pressure failure and fire damage to the gauge, pressure distortion of the gauge extension, pressure failure of the frangible disc safeties of the manifold.

The gauge was modified to be in agreement with Design Standard 531.2 excepting that the required restricting orifice was not included with the gauge. The dial of the gauge was not identified with a label reading "Oxygen--Use No Oil", therefore the service history of this gauge can be questioned.

R&D analysis of the oily film on the inside of the bourdon tube indicates the material to be hydrocarbon oil.

The following recommendations are amde to minimize reactions in gauges in oxygen service:

1. Examine all gauges 4½ inch or larger for compliance with or modified to Design Standards.

2. Test all gauges as required by I&M District Operations Manual, Section 3.1.2 or Operations Department Standard Procedure 1005.

3. Identify all gauges in oxygen service and use for no other service.

Original Signed By

W. W. Schmoyer

WWS/jmf

Encl.

Re-typed June 1, 1972
kfq

APCI DOCUMENT NO 99000257

AIR PRODUCTS AND CHEMICALS, INC.
Safety Department
WWSchmoyer/jmf

April 13, 1964

Investigation of Accident

Location: Specialty Gas Group, Plant #1, Emmaus, Pa., in the oxident-inert filling area.

Date: Approximately 4:30 P.M., March 23, 1964.

Equipment Involved: A six station gaseous oxygen transfilling cylinder manifold gauge exploded.

Personnel Injury: Employee H. Werst, an operator, received a bruise to his left hand. He was treated at the Trexlertown Medical Center and X-rays taken of his hand. He then resumed his normal working schedule.

Investigated by: W. W. Schmoyer

Description of Accident:

A six station, pedestal mounted gaseous oxygen manifold equipped with braided stainless steel pigtails was used in transfilling operations. All station valves are oxygen cylinder valves. One station valve was equipped with a fusible plug-frangible disc safety, and the other valves had frangible disc safeties. A 4½ inch, 0 to 5000 psi range back connected U.S. Gauge extended above face height, was part of the manifold.

A regulator was attached to one station valve on the right side of the manifold and was used to control transfilling pressures at 50 psig. The regulator and the station valve were open and in service.

One station valve was used as a vent valve and was closed. Three other station valves were closed and were equipped with pigtails.

The remaining station valve was closed with its pigtail connected to a full cylinder (pressure not known) of oxygen. The position of the oxygen cylinder was in the front of the manifold and slightly to the left.

The operator was standing at the right end of the manifold and noticed lack of pressure on regulator gauges. He checked regulator and station valves and found their settings satisfactory. Without changing his position the operator, with his left hand, reached across the manifold to the station valve to which the cylinder was attached and cracked it open slightly. At this instant, reaction took place within the gauge causing the plastic gauge glass to break and the gauge dial to eject from the case. The operator immediately dropped to the floor and moved behind some other cylinders. It was at this time he noticed sparks of the type associated with metal flame cutting. He then vacated the area and someone turned off the oxygen cylinder valve later.

Description of Damage:

Gauge:

1. Plastic gauge crystal was broken and blown from the case.
2. The gauge needle and dial was blown from the case.
3. The gauge rim was bent at the six o'clock position but remained attached to the case.
4. Both rubber gromet safety plugs were blown from their positions at five and seven o'clock on the side of the case.
5. A piece of the beryllium copper bourdon tube fractured at a point where it is attached to the stainless steel inlet connection of the gauge.
6. The inlet connection where the bourdon tube is attached was burned through.
7. A small hole was burned through the back end of the inlet connection.
8. The inside of the case was covered with a sooty deposit.

Gauge Extension:

1. The threaded end of the gauge where it screws into the manifold tee was bulged due to excessive pressure. The diameter at this point is about 3/32 inch larger diameter than the diameter of the 1/2 inch IPS extension.

Manifold:

1. The frangible discs on each of the station valves were blown.
2. The frangible disc--fusible plug safety on the vent valve was intact.
3. There was no evidence of combustion within the manifold.
4. The station valve which connected to the cylinder was disassembled and showed no evidence of combustion.

Investigation:

The service history of the gauge may be questionable even though it has been in service on this oxygen manifold for at least six months. The manifold is also used on occasion to handle water pumped nitrogen.

The gauge is not in agreement with the specifications set forth in Design Engineering Standard 531.2 which requires solid front construction, blow out backs, restrictive orifices at the inlet to the gauge, and the idal to be labeled "Oxygen--Use No Oil" if the gauge is for oxygen service. Existing gauges not complying with the Design Standard at the time of and prior to issue, were permitted to remain in service provided the gauge case was drilled and rubber gromet safety plugs installed, a plastic gauge glass installed, and a restricting orifice or snubber, per Design Standard 531.10.2, placed in the inlet connection to the gauge.

The gauge in question did not have an "Oxygen--Use No Oil" label attached to the gauge dial or a restrictive orifice or snubber at the inlet gauge connection.

The gauge was disassembled and the following noted:

1. The first mating surfaces where the gauge mechanism attaches to the inlet connection housing was covered with an oily substance. This material was analysed by R&D and determined to be hydrocarbon oils.

2. The bourdon tube was cut into two pieces at the terminal end of the tube. An oily substance covered the inside surface of the bourdon tube. This substance was analysed by R&D and determined to be hydrocarbon coils.

3. An analysis of the content of the cylinder involved indicates 12 ppm of hydrocarbon present in the oxygen. This concentration is considered normal.

Ignition:

The ignition source is believed to have been the temperature rise accompanying adiabatic compression as the station valve on the manifold was cracked.

Summary:

Upon cracking open the station valve to which the cylinder of oxygen was attached, the surge of oxygen through the manifold caused an adiabatic temperature rise sufficiently high to cause ignition of the hydrocarbon oil in the bourdon tube. The pressure is estimated to have been in excess of 8000 psig to cause distortion at the manifold end of the gauge extention and in excess of 3700 psig to rupture the frangible discs of the station valves.

Re-typed June 1, 1972
kfq

AIR PRODUCTS AND CHEMICALS, INC.

MEMORANDUM DATED JUNE 26, 1970

LOX PUMP FIRES AND EXPLOSIONS

B. J. Berrettini

DOCUMENT NOT AVAILABLE FOR GENERAL DISTRIBUTION

APCI DOCUMENT NO. 990002578

Air Products and Chemicals INC

REPORT OF TRIP TO GREAT LAKES STEEL CORPORATION

ECORSE, MICHIGAN ON JUNE 26, 1961

Folder P-59-24-2

PRESENT: S. H. Duffala and A. G. Piemme

SUBJECT: ACCIDENT AND FIRE IN OXYGEN GENERATING PLANT AT GREAT LAKES STEEL CORPORATION

Personnel Contacted: I. D. Akey, Superintendent of Combustion
J. Walls, General Foreman, Combustion
M. A. Jones, Senior Engineer

APCI DOCUMENT NO 99002552

SAFETY-GRAM

Air Products and Chemicals INC.

July 7, 1961
Number 3

Oxygen Compressor Fire

Late Wednesday afternoon, 21 June, 1961, a fire in an oxygen compressor at the Linde air separation plant, Ecorse, Michigan, resulted in the death of three men and extensive damage to the building and other equipment. Complete details are not known, and the following is a reconstruction of the event as reported in the newspapers and by people who visited the scene several days after the fire.

The 500 T/D Linde plant is leased and operated by Great Lakes Steel, and was designed for a high degree of automation. Product oxygen from the plant is compressed in a Clark, two stage, centrifugal compressor to 160 psi for delivery to the steel mill. Production in excess of the mill's immediate requirements is taken from the Clark compressor's discharge to a booster compressor, compressed to 625 psi and discharged to a gas storage system. The booster compressor is a Worthington, single stage, three cylinder machine of modified Y design. The central cylinder was vertical and the others were on each side at about 30° from the vertical. It was reported that the packing and piston rings were of glass-filled teflon.

The oxygen compressor room is walled off from the other half of the building which contains primarily the air compressors. The electrical switchgear for the oxygen compressors, and apparently that for the entire plant, are in the same room with the oxygen compressors. The office and control room for the plant is attached to the oxygen compressor room. The roof of the office and control room was used for storage and apparently was open to the compressor room. A six inch product oxygen line from the vaporizer also passed through the space over the office and control room.

Some difficulty apparently had been experienced with the Worthington machine as it is reported that various repairs and adjustments had been made during the three days prior to the fire. It is also reported that the operators' log for the shift prior to the fire had a note to watch the center cylinder as it was running hot. The machine evidently had been shut down and wash performed on the piston assembly on the afternoon of the 21st. The fire occurred at about 4:43 p.m., shortly after the compressor was put back on stream. Ignition appears to have occurred in the center cylinder and probably burned through to the oil in the crankcase. Apparently there was no true explosion, but a pressure release (160 psi suction pressure) when the cylinder melted through. The fire spread to the electrical motors and switchgear, and also to the combustibles stored above the office. The fire was intensified by oxygen discharged from the Clark compressor and also from the six inch line from the vaporizer, which melted or burned through after the combustibles on top of the office ignited. The air separation plant continued to operate until it was shut down by city firefighters. Ignition may have been the result of friction within the cylinder itself, or as the result of foreign matter entering during the repair operations.

This incident re-emphasizes the necessity for (a) keeping combustibles away from

APCI DOCUMENT
NO. 99000260

SAFETY - GRAM

pipe lines and equipment handling oxygen, (b) isolating as far as possible gaseous oxygen compression equipment from other equipment, (c) use of check valves and remote shut off valves so critical components can be isolated quickly, and (d) rigid adherence to high standards of cleanliness and accuracy in all maintenance and operations.

SAFETY DEPARTMENT
WLEall/jmf

Air Products and Chemicals INC

Put It In Writing

DATE October 21, 1963

TO Distribution

SUBJECT Report of Oxygen Pump Explosion

FROM W. L. Ball

Airco - Butler

Distribution:

C. R. Anderson	P. E. Engler	G. F. Pool
J. H. Arnold	G. Fedorko/L. Volland	L. P. Pool
R. D. Barclay	L. S. Gaumer	W. J. Scharle
B. F. Connor	J. Graeffe	C. J. Schilling
J. L. Cost	M. H. Halsted	C. W. Steele
D. E. Cummings	C. McKinley	R. L. Swope
E. J. Donley	J. J. Mittleman	

On March 6, 1963 Airco experienced an explosion in a reflux oxygen pump at one of their plants at Butler which killed one man, hospitalized three more, and did extensive damage to the air separation equipment. Enclosed for your information is a copy of a report of this incident that was presented at the recent A.I.Ch.E. Air and Ammonia Plant Safety Symposium. Although we do not have liquid pumps in this service, the same type of incident could occur in other liquid oxygen pumps. In reviewing the recommended corrective action, similarity with our own operations is of interest.

1. Although we do not inert liquid oxygen pumps before placing them in service or removing them from service, whenever it is necessary to hold a pump in a cold condition it is done with nitrogen rather than with oxygen.

2. Our vertical B-J pumps have a drain in the bottom of the pump barrel so that all material can be blown out or drained from the low point during defrost.

3. Flexible hoses are used only for transfer of product and not on the process equipment itself.

4. Considerable attention is given to providing an adequate fire protection system for the tonnage oxygen facilities. With exception of Acme, each plant is considered to have an adequate fire water system with the capability of providing large quantities of water to all elements of the facility. Modifications to the Acme facility have been recommended and are under study.

5. A program for solvent washing the cold box equipment associated with oil lubricated compressors has been under development for several years. Recommended washout schedules for each of these plants has been developed.

ORIGINAL SIGNED BY

W. L. Ball

WLB/jmf
Encl.
(Retyped September 25, 1972, cju)

99000261

DESCRIPTION OF AN AIR SEPARATION PLANT EXPLOSION

BY: J. J. Rendos
Air Reduction Sales Company
Division of Air Reduction Company, Inc.
Jersey City, New Jersey

ABSTRACT

An explosion in an oxygen circulating pump and connecting piping is described. The accident was caused by an ignition of combustible contaminants in the pump and connected piping. The source of ignition is unknown.

REPORT

On Wednesday, March 6, 1963, at 11:08 A.M. an explosion occurred in an oxygen circulating pump and connected piping. The resulting fire involved refrigerating and associated equipment. This accident was caused by the ignition of combustible contaminants in the oxygen pump and connected piping. The source of ignition is unknown. The violent fragmentation of the cast bronze pump body and associated equipment caused considerable damage and personal injury. The ruptured pump and associated pipe equipment were built according to code requirements. The violence of the explosion was such, that piping, pump parts, and cold box panels were ruptured.

This plant manufactures liquid oxygen, nitrogen, and argon in addition to pipeline oxygen and nitrogen. Due to the increased argon demands, a modification was made to the primary air-separation column of one of the units. This consisted of adding more rectification plates between the argon attachment and the reboiler. This secondary column was so installed that it was necessary to take liquid oxygen from the present (low-pressure) primary column and to pump the liquid to the newly installed column. (See simplified flowsheet, page 6).

HISTORY OF ACCIDENT

Four employees were engaged in starting up the liquid oxygen reflux pump on Unit No. 3 after an eight-day shutdown for maintenance and derime. The function of this reflux pump was to transfer liquid oxygen from the bottom of the primary oxygen column to the top of the secondary oxygen column.

The oxygen reboiler, reflux pump and associated piping were last washed (using chlorothene) on March 20, 1962. Unit No. 3 was shutdown on February 26, 1963 for maintenance work and derimed on March 5. After a complete derime, the column was cooled and had been running for 16 hours when the procedures for starting up the secondary column by the use of the oxygen reflux pump began.

The reflux pump shaft was free when the liquid oxgyen inlet valve to the pump was first opened. However, the pump froze and could not be started. The inlet valve was closed and the pump bowl heated externally. This was accomplished by applying steam to the bowl of the pump. The steel panel and the insulation from the west side of the pump were removed for this procedure. When the pump shaft could be turned by hand, one of the men, who was standing on the west side of the pump housing, started to reopen the oxygen liquid inlet valve slowly. The oxygen gas vent valve and the outlet liquid oxygen valve were already open in preparation for starting the pump. Before the pump was started and when the inlet oxygen liquid valve was opened, and explosion occurred.

The inlet, outlet and vent lines within the insulated pump housing had ruptured from an internal explosion as well as the 4" inlet line inside the cold box leading from the bottom of the primary oxygen column to the pump impeller casing. The impeller casing explosion blew several pieces through the end steel insulation panel. The violence of the detonation forced the vertical pump shaft upwards with sufficient momentum to break loose the motor and casing on top of the shaft mount throwing the motor 25 feet to an overhead platform above the refrigerating equipment. The pipeline explosion blew the panels from the east side of the pump housing and from the side of the cold box immediately in front of the pump, blew rock wool and fragments of the three pipelines around the area. This started an oxygen-fed fire at the refrigerating equipment several feet in front of the pump. The fuel being a mixture of Freon 12 (dichlorodifluoromethane) $C Cl_2F_2$ and lubricating oil. Evidence of burning at the copper braid covering of the ruptured flexible hoses indicated that some combustibles were present in the hose lines.

DISCUSSION OF ACCIDENT

The damage was apparently caused by internal explosions:

1. In the 4" and 3" copper lines at the bottom of the primary column to the oxygen reflux pump,
2. In the pump impeller casing,
3. In the oxygen reflux pump line to the secondary oxygen column,
4. In the vent line branching from the inlet line, and
5. In the baffle support pipe stiffener in the oxygen reboiler.

The series of coincidental ruptures in the pump and oxygen lines indicated that a detonation had occurred and that the pump and piping contained appreciable quantities of combustible in contact with the liquid oxygen. The combustible was probably lubricating oil which had accumulated in the system over an eleven-month service period and that had been left after the derime in a plugged sump in the base of the pump impeller casing and in the crevices of the bellows-type flexible hoses which had been installed with their axes horizontal.

The source of ignition could have been violent turbulence in the base of the pump caused by cold liquid meeting a warm heavy metal pump piping. Any liquid that reached the pump would boil violently because of the high heat capacity of the heavy metal parts. Although oil by itself would not be expected to ignite in liquid oxygen, even when violently agitated, the presence of solid acetylene could sensitize the oil to ignition by turbulence. The column had just been derimed. It would not be expected to show accumulations of acetylene above the solubility limit in the liquid so soon after a derime. The other three units, which were tested for acetylene before they were restarted after the explosion, showed no acetylene except for the usual trace in the scrubber.

There is a remote possibility of chlorothene, which is combustible in oxygen, being present but the probability is so low that the possibility is not worth considering. It seems reasonably certain that lubricating oil was the sole combustible. The pump casings on the oxygen transfer pumps showed lubricating oil when disconnected and inspected internally after the explosion and fire. Also, some unbrazed sections of lapped joints in the silver brazed copper inlet line showed evidence of explosion inside the lap joint where oil had probably collected. When the outer female copper joint bulged, the inner or male connection bulged inwards tearing open the silver brazed joint revealing unbrazed areas which had not been thought to exist. Some unconsumed oil was still noticeable in one area inside the ruptured pipe.

CONCLUSIONS

1. The internal explosion in the pump and associated piping was probably caused by the rapid combustion of lubricating oil that had collected since the last washing period, March 20, 1962, and that had not been removed by the deriming operations (March 5, 1963).

2. The oil accumulations was trapped in the convolutions of the bellows-type flexible hoses, mounted with axes horizontal and in the plugged sump in the pump bowl.

3. The cause of ignition is not known although it might have been turbulence in the hot pump when admitting liquid oxygen possible sensitized by the presence of frozen acetylene.

CORRECTIVE ACTION

1. (a) The cold box oxygen transfer pumps similar in construction and service to the oxygen reflux pump will be cooled and inerted with liquid nitrogen before using them in liquid oxygen service.

   (b) Before doing any maintenance work on the transfer pumps, such as, thawing or repairing, the liquid oxygen pumps will be inerted with liquid nitrogen.

2. Drains will be provided in all oxygen transfer pump bowls in the boss at the center of the casing. This is the low point.

3. In the future, all flexible hoses in liquid oxygen service will be installed with axes vertical.

4. The combustibility hazard of Freon 12 refrigerating equipment will be examined to determine need for less exposed positions or for automatic sprinkler protection.

5. All plants will be equipped in the engine rooms and near cold boxes with large fire hoses connected to a suitable source of water. These hoses are to be equipped with fog nozzles. This accident proved once and for all the advisability of installing such equipment in the engine room. The damage would have been many times as great were it not for the hoses and fog nozzles supplied to this plant.

6. All air separation unit cold box equipment will be solvent washed so long as oil lubricated compressors are used.

7. In Unit No. 3, the following procedure was followed in the main cold box to eliminate the oxygen reflux pump.

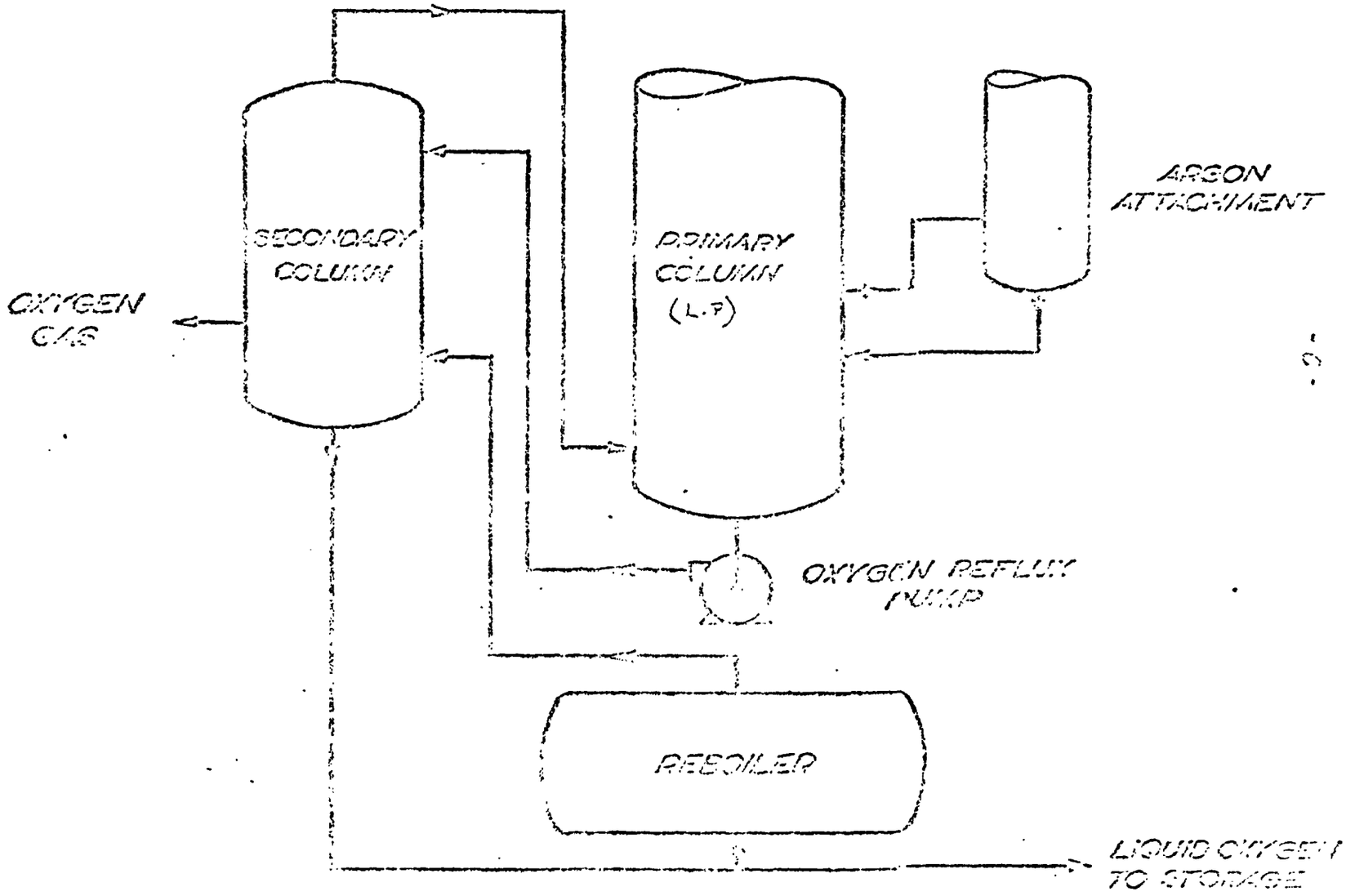
   (a) Isolated secondary oxygen column.

   (b) Connected oxygen column reboiler to the primary oxygen column.

   (c) Blanked the derime valve to the primary oxygen column.

Re-typed June 5, 1972
kfq
(original typed pages numbered 5)

SIMPLIFIED FLOW SHEET



REPRODUCIBILITY OF THE ORIGINAL COPY IS POOR.

Air Products and Chemicals INC.

AIR SEPARATION PLANT FIRE

by

J. J. Rendos

Safety in Air and Ammonia Plants

Volume 6, PP41-4, 1964

APCI DOCUMENT NO 99000261A

Air Products and Chemicals INC.

OXYGEN FIRES

by

S. W. Cowles

Safety in Air and Ammonia Plants

Volume 8, PP19-20, 2P,

1966

APCI DOCUMENT NO 19000262

Air Products and Chemicals INC.

LIQUID OXYGEN PUMP FAILURES

by

J. J. Rendos

Airco RE-99000301

APCI DOCUMENT NO 9900263

Air Products and Chemicals, Inc.

Put It In Writing

DATE December 29, 1967

TO All Plant Managers SUBJECT Oxygen Pipe Line Failure

FROM H. H. Master

cc: W. English
D. Fox
M. Halsted
R. Hatley
M. Hubbs
F. Iobst
W. Say
W. Scharle
T. Straughan
H. Wynn

In November 1967 there was an oxygen pipe line fire in a steel mill in India. A steel mill, with the assistance of an oxygen company technical staff, was in the process of installing a scarfing machine, although at the time of the fire the scarfer was not in operation and, in fact, was not yet connected to the oxygen line. The main supply is 8 inches in diameter and approximately 400 feet long. A 4 inch diameter drop line from the main header connects to the scarfer. Technicians had, a few minutes prior to the incident, been setting the timing on emergency cut-off valves at the scarfing machine. When the oxygen line was pressurized for the first time, a fire originated in a line filter, essentially consumed the filter and also burned through an elbow immediately downstream of the filter. The filter case material is not known but the filter element was stainless steel, 60 mesh.

Six people were standing relatively close to the filter which, unfortunately, was located in a rather crowded and confined area. Those six people were killed.

Even though we do not know the details on operating and cleaning, this incident serves as a reminder on several safety rules which have been issued in the past:

1. Rigid cleaning and inspection of materials used in oxygen transmission lines.
2. Slow opening of valves.
3. A minimum of personnel in the area on initial pressurization or testing of equipment and remote operation where possible.

ORIGINAL SIGNED BY

H. H. Master

HHM/may
(Retyped September 25, 1972, cju)

APCI DOCUMENT NO. 9900264

Air Products and Chemicals INC.

PUT IT IN WRITING

Date: December 30, 1968

TO: Distribution

Subject: LOX Transfer Pumps

FROM: H. Master

Distribution:

All Plant Managers
W. L. Ball*
J. H. Colby*
J. J. Dwyer*
G. Fedorko APL
M. H. Halsted
P. F. Newman*
A. W. Norman*
R. D. Paige*
W. T. Rector*
G. W. Robinson
W. J. Scharle*
J. L. Stolz
M. Vogel APL
H. E. Wynn
M. Xiques
J. H. Arnold
C. Z. Howell
R. McVickers
E. P. Thomas

*attended meeting

A meeting was held 12/27/68 with regard to 2 LOX pump (Paul) incidents which Airco had within a matter of hours of each other. In the first case there was no gearbox bearing failure and it was believed foreign matter got into the pump and, due to close tolerances, resulted in frictional heat and fire. In the second case there was a bearing failure and the operator heard the squealing in the gearcase and shut the pump down. There was no fire in this second pump. It was explained that these pumps do not have any bearings in the pump itself. They are dependent on tolerances set in the gearbox bearings, etc. to prevent rotating parts from hitting the case. This construction is the reason for theorizing foreign material in the impeller area caused the one fire.

Some items brought out at this meeting were:

1. Most plant pumps are BJ. All those for customer supply have suction filters.
2. IGD has not had a problem with trailer pumps. It is believed all their pumps have suction filters but P. Newman is going to check this out. It is also believed Halocarbon oil is used in the gearcases.
3. Granite City has had a history of foreign material in the Tyree pump and has had a filter installed.

Action determined necessary as a result of the meeting:

1. Install conical screens on all pump suction lines. C. Howell will review piping and practical installations are to be worked out for the individual plants. This is to be done by January 15, 1969.
2. J. Dwyer will check to be sure SoCal has filters included.
3. W. L. Ball will check on pump histories at APL. APL is to be notified of these problems and assist W. L. Ball as requested in gathering this information.
4. Screen inspections and cleaning are to be on a 6 months frequency and are to be included in the PM program. They will also be done during any pump disassembly or repair but the 6 months interval must be set up to take care of those instances where operation and repairs are infrequent.
5. There were a few questions on the attached pump summary which the writer was to investigate. Answers are handwritten on the attached.

APCI ATTACHMENT NO. 9000245

Air Products and Chemicals INC.

Via copy of this memo, plant managers are:

1. Advised of the incident so they can act accordingly.
2. Advised they are to install screens on similar pumps if they are not already provided. Engineering will provide details per item 1 (action) above.
3. Review the attached summary and advise the writer of any corrections or additions they may have for this listing.

The high speed product pumps at Lone Star are probably our most critical pumping application using Paul pumps and they have a line strainer installed.

ORIGINAL SIGNED BY

H. H. Master

FOR IN WRITING

Revised January 2, 1969

TO: W. J. Scharle

DATE December 20, 19

FROM: J. L. Stolz

SUBJECT: LOX Transfer Pumps

Location	Section	Brand	Model	GPM	(Ft) (psi) Head	RPM Speed	Suction Line Filter	Remarks
Wharton	10.20	Paul	1-1/2X2-1/2X6	28	100 Ft.	3600	Yes per flowsheet	
Wharton	10.22	Paul	2X4X6	200	100 Ft.	3500	Yes	
Lone Star	10.20 A&B	Paul	1-1/2X3X6	60	800 Ft.	8200	100 Mesh	Customer back-up pump
Lone Star	10.22 (Transf)	Paul	2X4X6	200	100 Ft.	3500	100 Mesh	Loading Pump
Middletown	10.22	Cosmodyne		200	150 Ft.	3550	No	
Granite City	10.70 IGD	Paul					No	To off load mobile equip. Very little use.
Granite City	17.60 IGD	Tyree-Recip					Yes	Constant plug up of 100 Mesh strainer-sandy mat'l.
Santa Susana	2 1/2 ea.	Turbocraft	2X4X7.37	250	140 Ft.	3600	No	To pump from storage bldg. to vacuum tanks.
Sparrows Point	10.50	Paul		200	75 psi		No	
Sparrows Point		Carter		150	150 Ft.	3600	No	
Sparrows Point	10.22	Carter		200	75 psi	3600	No	
Lathrop	10.20	Paul	2-1/2X3X8-1/2	200	75 psi	3600	No	
Weirton								No transfer pumps
Cleveland 2 ea.		Turbocraft	2X4X7.3	200	172 Ft.	3600	No	Removed from service
Chicago		Tyree Recip					Yes	
Ashland	10.22	Paul	2X4X7	200	75 psi	3600	No	
Cleveland	17.61A						No	Removed from service

Location	Section	Brand	Model	GPM	(Ft) (psi) Head	RPM Speed	Suction Line Filter	Remarks
Cleveland	17.61B	DRI-Recip					Yes per Flowsheet	Removed from serv
Cleveland		Paul D10150		5	3000 psi	900	Yes	For pumping cylinder
Burns Harbor	10.30	Carter	12-1/4"z1205/8"X31"	200	75 psi	3600	No	
New Orleans	10.20 A&B	BJ	Barge Loading	3200	230 Ft.	1750	No	Not used
New Orleans	10.22 1 ea.	Cosmodyne	RR Loading	200	157 Ft.	3530	No	
New Orleans	10.31 A,B,C	Cosmodyne	Loading Station	200	157 Ft.	3530	No	
New Orleans	10.97 A,B	BJ	Product	30	132 Ft.	1750	No	
Creighton	Cyl. Loading	Paul	2 MPD 10150	25,000 SCFH	3000 psi		Yes	
Delaware City (RR)	10.30	Paul	2X4X6-1/2	200	75 psi	3600	No	
Delaware City	10.50	Paul	1-1/2X2-1/2X6	28	50 psi	3600	No	Not being used
Decatur, Ala.	10.20	Carter		22	26 Ft.		Yes	
Decatur, Ala.	10.22	Paul	2X4X6	200	100 Ft.	3500	Yes	
New Johnsonville								No transfer pumps
Pittsburgh								No transfer pumps
Chicago	(RR)	Paul	D10615-2	200	75 psi	3500	No	

ORIGINAL SIGNED BY

J. L. Stolz

JLS:jid

(Retyped 9/25/72 sba)

Air Products and Chemicals INC.

PUT IT IN WRITING

TO: Distribution

Date: January 24, 1969

FROM: H. Master

Subject: LOC Transfer Pump Screens

Distribution:
T. M. Beckowski
T. R. Bosley
J. E. Graham
D. Harris
J. K. Helferty
J. M. Norwood
G. H. Shelborne
M. D. Thompson
L. L. Volland
S. W. Voxburg

cc: J. H. Colby (no attachments)
M. H. Halsted "
G. W. Robinson "
W. M. Say "
W. J. Scharle "
H. E. Wynn "

On December 20, 1968 the writer issued a memo outlining a history of pump fires and failures Airco has had recently. It was believed foreign material got into the pumps and caused the problems. As a result it was decided we would put screens in all our transfer pump suction lines and Engineering was assigned to review prints and determine where they could be installed, what screen could be put in, and determine materials and costs of same.

Attached are prints, sketches, or flow sheets for your respective plants which have been marked to show the installation. A bill of materials to do the job is also included on these marked sheets. Also, attached is a tabulation of materials required to do the work on each pump and the estimated cost for the materials. The plate flange listed for most screen systems (Item 7) is an APCI standard 579.2.4-13, a copy of which is attached.

Installation of these screens is urgent. I will be calling each of the plants involved on Wednesday, January 29. Meantime, check the prints or sketches and see if your piping has not been changed, the proposed method of installation is satisfactory and bill if materials is adequate. When I call I would like to know if you need any further help in this matter. Also, confirmation of the bill of materials will prompt me to order the cone screens (100 mesh) only from here. Other items, excepting the brass flanges, are standard and it would expedite matters if you ordered them locally. Screens are standard and a weeks delivery has been quoted.

1990366

Air Products and Chemicals INC.

As far as the flanges are concerned they shall be made locally if at all possible. It will take us five to six weeks to get the material here and two weeks to have them made. They will cost $35 each. When I call we can also discuss this matter if there is a problem.

This is an urgent safety item and all screens should be installed with a month and earlier if possible. If any assistance is required, contact the writer.

ORIGINAL SIGNED BY

H. Master

HM:sl

Attachments

Retyped 9/25/72 sba

Tabulation

Materials Required for LOX Pump Strainer Installation

B/M No. Location	Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Cost
Middletown	10.22			2				8			32	64	64		4			$ 525
Santa Susana				2														$ 200
Sparrows Point	10.50	1							2		4	8	8	1				$ 300
Sparrows Point	Portable		1															$ 77
Sparrows Point	10.22				1			2			4	8	8		1			$ 155
Lathrop	10.20		2					4			8	16	16		2			$ 300
Ashland	10.22		1					2			4	8	8		1			$ 150
Burns Harbor	10.30				1			2			4	8	8		1			$ 155
N · Orleans A	10.22						1											$ 100
New Orleans	10.31			3				6			12	24	24		3			$ 525
New Orleans	10.97		2					4			8	16	16		2			$ 300
Delaware City	10.30					1												$ 77
Chicago	R.R.	1								2	16	32	32			2	1	$ 365
Granite City	10.70		1						2		4	8	8		1			$ 155
Totals		2	7	7	2	1	1	30	2	2	96	192	192	1	15	2	1	$3384

Notes: A. Dwg. 3-1681-57-238E presently shows a suction strainer installed. Verification of its presence should be made prior to this purchase.

Bill of Material

1. Strainers, 4"-150# R. F., Type 304SS, Mack Iron Works "PCS", 100 mesh SS Screen (outside liner)

2. Strainer, 3" -150# F. F., Type 304SS, Mack Iron Works "PCS", 100 mesh SS Screen (outside liner)

3. Strainer, 4" -150# F.F., Type 304SS, Mack Iron Works, "PCS", 100 mesh SS Screen (outside liner)

4. Strainer, 2 1/2"-150# F.F., Type 304SS, Mack Iron Works "PCS", 100 mesh SS Screen (outside liner)

5. Strainer, 4"-150# F.F., Type 304SS, Mack Iron Works "FFP", 100 mesh SS Screen

6. Strainer, 4"-150# F.F., Type 304SS, Mack Iron Works "PES", 100 mesh SS Screen (outside liner)

7. Flange, Brass, APCI Std. 579.2.4-13

8. Flange, 3"-150# R.F., Weld Neck, Type 304SS

9. Flange, 4"-150# R.F., Weld Neck, Type 304SS

10. Studs, S.S. Type 304, 5/8-11 X 3 3/4 lg., ASTM A320 Sym B8, Code No. 7-820-69-1496

11. Nuts, SS Type 321, Hex Hvy, 5/8-11, ASTM A194 Sym 8T, Code No. 7-592-69-0057

12. Washers, SS, 5/8", Code No. 7-961-69-1020.

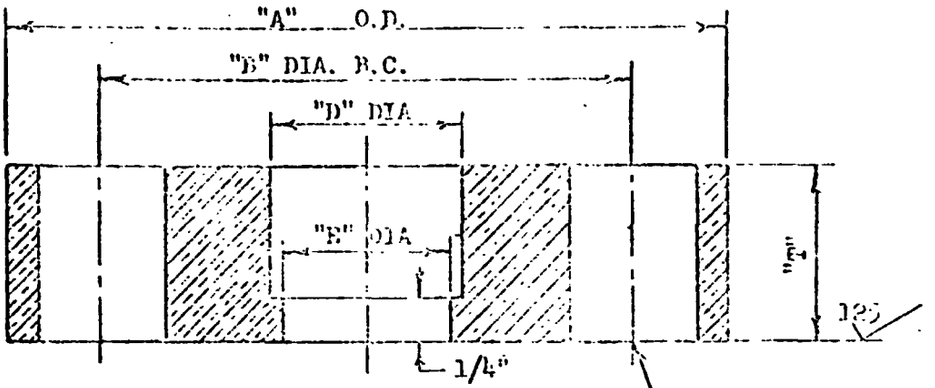
13. Gasket, 7-372-03-0422, 3 1/2" X 5 3/8" Flt. Ring - 1/16" Garlock 900 (ASA B16.21)

14. Gasket, 7-372-03-0160, 3 1/2" X 7 1/2", Full Face - 1/16" Garlock 900 (ASA B16.21)

15. Gasket, 7-372-03-0428,4 1/2" X 6 7/8", Flt Ring - 1/16" Garlock 900 (ASA B16.21)

16. Pipe, 4"-Sch. 40, ASTM A312 Type 304, 8" lg. IG Welded, Plain ends.

PLATE FLANGES — 150# FLAT FACE — BRASS



"F" = No. & Dia. of Bolt Holes Equally Spaced

PART NO.	SIZE	A	B	C	D	E	N	T*	DESIGN PRESS.	MATERIAL CODE NO.
8.	1	4 1/4	3 1/8		1.128 1.131	1	4 5/8	3/4	220	1-671-05-0029 3-346-05-0029
9.	1 1/4	4 5/8	3 1/2		1.378 1.381	1 1/4	4 5/8	3/4	220	1-671-05-0030 3-346-05-0030
10.	1 1/2	5	3 7/8		1.628 1.631	1 1/2	4 5/8	7/8	220	1-671-05-0032 3-346-05-0032
11.	2	6	4 3/4		2.128 2.131	2.	4 3/4	1	220	1-671-05-0034 3-346-05-0034
12.	2 1/2	7	5 1/2		2.628 2.631	2 1/2	4 3/4	1	220	1-671-05-0035 3-346-05-0035
13.	3	7 1/2	6		3.128 3.131	3	4 3/4	1 1/8	220	1-671-05-0036 3-346-05-0036
14.	4	9	7 1/2		4.128 4.131	4	8 3/4	1 1/4	220	1-671-05-0038 3-346-05-0038
28.	6	11	9 1/2		6.128 6.131	6	8 7/8	1 3/8	220	1-671-05-0039 3-346-05-0147

NOTE: 1. These flanges are designed for use with 1/16" thk. compressed asbestos "Garlock 900" full face gaskets.

2. Material to be used - Naval Brass Plate ASTM B171, "T" thick by "A" dia.

3. Reducing flanges of this rating are listed on Pages 8 & 9.

* Tolerance is ± 1/32"

Air Products and Chemicals, Inc.

All information herein is the confidential property of Air Products and Chemicals, Inc., unless another source is shown, is subject to return on demand and must not be disclosed or reproduced without prior written consent.

Date Oct. 1966

Air Products and Chemicals INC

Put It In Writing

DATE January 26, 1971

TO W. J. Scharle* SUBJECT Paul, Carter, and Cosmodyne

FROM R. D. Stompler* LOX Pump Safety

Dist: W. L. Ball, B. J. Berrettini, M. H. Halsted, F. A. Jobst, H. H. Master, A. W. Norman, R. D. Paige, W. T. Rector, G. W. Robinson*, J. L. Stolz*, E. P. Thomas*, H. E. Wynn, M. H. Vogel - APL, J. M. Geist*

Available history of centrifugal LOX pumps failures of Paul, Carter, and Cosmodyne manufacture indicates that catastrophic mishaps of the type recently experienced at our Puerto Rico Facility have occurred only on pumps operating at relatively high speeds (above 3600 RPM) and have mostly been associated with internal rubs resulting from bearing failures. (The second most common cause is ingestion of debris.) As well as can be determined from discussions with APCI personnel, no dramatic failures have occurred on the 3600 RPM low head, high volume transfer pumps in APCI or in other companies in the industry and, therefore, incidents must be considered very rare, if even existant.

A meeting was held on January 20, 1971 (attendees indicated by asterisks (*) to discuss the safety and reliability aspects of these pumps and the following recommendations were made.

For the five (5) high speed LOX pumps now in service under the APCI operations department (two at Lone Star @ 8600 RPM, two at Puerto Rico @ 9400 RPM, and one at Burns Harbor @ 11,400 RPM), the recommendations were:

1. Installation of "Type II Safety Modifications Kits".
2. Installation of appropriate safety barriers.
3. Installation of suction screens.
4. Installation of nitrogen purge on gear cases.
5. Installation of bearing temperature alarm and shutdown systems.

Below is a status tabulation of the five units now in service relative to the listed items:

Item Description	Burns Harbor	Lone Star		Puerto Rico	
		A Unit	B Unit	A Unit	B Unit
Type II modif. kit	Installed	Installed	Installed	Installed	Installed
Protective Barriers	None	Installed	Installed	Installed	Installed
Suction Screens	Installed	Installed	Installed	Installed	Installed
Nitrogen Purge	Installed	Installed	Installed	Installed	Installed
Bearing Temperature System	None	To be Installed	To be Installed	Installed	Installed
Forced Feed Lube System	Not Necessary	Not Necessary	Not Necessary	Installed	Installed

APCI DOCUMENT NO. 1000267

Air Products and Chemicals INC

Put It In Writing

DATE January 26, 1971

TO W. J. Scharle SUBJECT Paul, Carter, and Cosmodyne

FROM R. D. Stompler LOX Pump Safety

The most glaring deficiencies are at Burns Harbor which has neither protective barriers nor a bearing temperature protection system and which puts the operator in direct view of the pump at a distance of about ten feet during startup and shutdown. Action on the bearing temperature system is being initiated by A. W. Norman and the installation of protective barriers is being handled by H. H. Master.

For the slower speed (3600 RPM) transfer pumps of which APCI Operations has some 25 in service, the recommendations were:

1. Installation of protective barriers:
   Protective barriers of single sheet corrugated steel should be erected around all stationary LOX pumps. For portable units, a substantial shroud type shield should be installed around the pump end to afford as much blast protection as is feasible.

2. Installation of suction screens:
   Suction screens are a must on all LOX pumps with a few exceptions specifically cleared through safety and all available records show that these screens have already been installed.

For future purchases and installation, it is recommended that all LOX pumps, regardless of type or service, be installed with an adequate form of protective barrier and that all purchases of new LOX pumps be specified with super safe parts, as the additional cost for these on original orders would be quite reasonable (about $150).

ORIGINAL SIGNED BY

R. D. Stompler

RDS/lmg

(Retyped September 25, 1972, cju)

Air Products and Chemicals INC.

Put It In Writing

DATE February 19, 1971

TO M. H. Halsted SUBJECT LOX Pump Safety

FROM R. D. Stompler

cc: L. W. Ball, W. K. Corey, J. M. Geist, H. H. Master, A. W. Norman, J. D. Poe, W. T. Rector, G. W. Robinson, M. H. Vogel - APL, H. E. Wynn

Referring to the writer's memo to W. J. Scharle of January 26, 1971, concerning Paul, Carter and Cosmodyne LOX pump safety, all five (5) high-speed, high-pressure LOX pumps now in service by the APCI Operations Department (all Paul Mfg.) have been provided with the recommended safety barriers. Bearing temperature protection systems have yet to be installed on the Burns Harbor unit, and the two Lone Star machines. The necessary equipment for these installations is presently on order with delivery dates of 4/23/71 and 3/12/71 for Burns Harbor and Lone Star respectively. (An effort is being made to improve these delivery dates.)

Installation of the systems should require no more than two or three days each and will be performed at the earliest possible opportunity.

Completion of this work will accomplish all of the recommendations set forth for these units in the afore-referenced memo.

ORIGINAL SIGNED BY

R. D. Stompler

RDS:rsb

(Retyped September 26, 1972, cju)

APCI DOCUMENT NO 2900268

Air Products and Chemicals INC.

FIRE TESTS ON CENTRIFUGAL PUMPS FOR LIQUID OXYGEN

by

H. Bauer
W. Wegener
K. F. Windgassen

Cryogenics, Volume 10, PP241-248,
8P, June, 1970.

APCI DOCUMENT
NO 19000269

AIR PRODUCTS AND CHEMICALS, INC.
Safety Department
WWS, July, 1965

SAFE HANDLING OF REGULATORS AND TORCHES

The use of regulators is required in many applications where the use pressure of a fluid or gas is lower than the supply pressure. In the metal industry, oxygen is used with a fuel gas to obtain the necessary heat to cut or weld metals. The supply of gases is contained in cylinders at pressures well above the use pressures. Oxygen cylinder pressures may be as high as 2600 psig while use pressures may normally be up to 60 psig. Fuel cylinder pressures vary with the type of fuel gas used and may be as high as 250 psig and, in some cases, to 2500 psig while use pressures may normally be up to 15 psig. Regulators, therefore, become a vital and necessary piece of equipment in controlling the pressure reduction.

It is important to be familiar with the physical properties and the hazards of the gases used in the metal welding and cutting processes. The fuel gas (acetylene, hydrogen, propane, butane, natural gas, and others) are flammable when mixed with the proper amounts of air and, under controlled conditions, can be handled safely. The hazardsassociated with flammable gases are fire and explosion. Oxygen, although nonflammable, supports combustion and reacts chemically with most materials, some with violence. The hazard with oxygen is minimized in the selection of materials which are least likely to react under normal use conditions. The attached Safety-Grams cover some of the products, their properties and safety considerations, that are used in the oxy-fuel system for metal cutting and welding.

Many accidents have occurred in the industry, causing injury to personnel and destruction of property. Most of the accidents involved fire or explosion of

APCI DOCUMENT NO 99000270

the oxygen regulator, chiefly because of the reactivity of oxygen with some of the materials that can be part of or contaminate the system. The industry has recognized this hazard through studies extending over the past 20 years. Results of these studies led to an understanding of the causes and the design improvements necessary to minimize the recurrence of the accidents.

Most oxygen regulator accidents occur when:

1. An empty oxygen cylinder is replaced with a full cylinder, and the cylinder valve is opened for the first time.

2. The torch is lighted after the equipment has been standing out of service for a period of time with the equipment under pressure.

3. A pressure adjustment is made at the oxygen regulator while the equipment is in service.

The causes of the accidents are:

1. Oil and grease on or entering the inlet connection of the regulator and the oxygen cylinder valve outlet.

2. Dust, dirt, and scale from the cylinder or cylinder valve entering the regulator.

3. Faulty regulators.

4. Improper operation of the equipment.

5. Disregard for established safety regulations.

6. Inadequate operator training and inexperience.

7. Flammable mixture of oxygen and fuel in the regulator, hoses, and torch.

For a fire or explosion to take place, it is necessary to have three elements present--oxidant (oxygen), fuel, and the means of ignition. Almost any material is fuel in an oxygen regulator--the metal parts, the seats, etc.; however, these materials have high ignition temperatures and are difficult to ignite initially. Ignition sources take the form of open flame, high temperature, impact energy, friction, electric spark, and static spark. The ignition sources possible in a regulator fire are:

1. Open flame from the end of the torch causing propagation of the flame back to the regulator if a flammable mixture is present in the system and under static or extremely low flow conditions.

2. Impact energy as particles of dirt or scale from the cylinder which enter the regulator and strike the passage walls or seat area.

3. Friction caused by high velocity flows.

4. High temperature caused by the recompression of oxygen as it enters a dead-end passage of the regulator when the cylinder valve is opened quickly. It is possible, theoretically, for temperatures to reach as high as 1700° F. during this recompression period.

Improvements in the design of the regulators have been directed towards minimizing the possibility of ignition occurring. Materials selected for their ability to perform must have as high an autoignition temperature as possible above the normal use temperatures expected in the regulator. The filters at the inlet connection and at the regulator seats provide protection against impact energies by stopping dirt particles from entering the regulator. The

filters also act to change the velocity of the oxygen and reduce the possibility of heat from friction, as well as dissipate any heat from recompression.

The manufacturer of the regulating equipment, having recognized the hazards, has taken steps to minimize the possibility of accidents through material selection, addition of filters, and quality control. In addition to this, he has published instructions which, if followed, will minimize or eliminate the exposure to the operator. It is in this area of equipment use where the manufacturer has no control and the area where, after investigation of accidents over the past several years, a violation of basic safety rules may have been a contributory cause of the accident. The industry has been instrumental in the establishment of safety regulations concerning regulator use by the public. Some of these publications are listed below:

1. Compressed Gas Association (CGA) pamphlet P-1, "Safe Handling of Compressed Gases."

2. Various publications of CGA listing the properties, hazards, and safety recommendations of various gases used in the compressed gas industry.

3. American Welding Society's "Safety in Welding and Cutting" (American Standard Z49.1).

4. National Fire Prevention Association (NFPA) bulletins 51 and 51B, "Welding and Cutting, Oxygen--Fuel Gas Systems" and "Cutting and Welding Processes," respectively.

5. Individual instructions packaged with each piece of equipment manufactured.

6. Welding schools conducted by some manufacturers of equipment.

Attached is a bibliography of readily available references pertaining to safety in handling, use, and storage of compressed gases and related equipment. Copies of operating procedure are also attached and are typical of the type instructions the industry considers necessary.

The manufacturer of the equipment has the responsibility of designing safety into his product and providing information regarding the hazards associated. It is the responsibility of the user of the equipment to exercise the safety instructions and recommendations of the manufacturer. Training and communication are, therefore, vital in minimizing the accident potential.

In our experience of the past several years, a violation of established safety rules was contributory to the accidents reported. Of those accidents where a complete investigation was made, the user easily recognized where his action was contributory with the result that legal action did not become involved, although personnel were injured. The likelihood of legal action increases where the investigation of an accident is not made immediately following the accident, or if it is made by an investigator not thoroughly familiar with the equipment involved.

The common typesof violations of safety practices on the part of the user are listed as a guide in the investigation of accidents:

1. Not checking regulator inlet or cylinder valve outlet for cleanliness before making connection.

2. Opening the oxygen cylinder valve quickly.

3. Not releasing regulator adjusting screw before opening cylinder valve.

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4. Handling regulator and cylinder valve with oily and dirty gloves.

5. Not venting hoses prior to lighting torch to remove possible flammable mixture in system, particularly after equipment has been out of service for a period of time with all valves set at service positions.

6. Using incorrect pressures for the equipment in use.

7. Using equipment which is faulty or the incorrect size for the job to be done.

8. Attempting to repair equipment without a thorough knowledge of what is required.

9. Stopping operations for the day without completely closing all valves and venting the system.

10. Experience and training of operator.

11. Lighting the torch from an open flame source.

Other general points to consider in the investigation of an accident are:

1. Condition of the accident area.

   a. Crowded working conditions.

   b. Poor housekeeping.

   c. Presence of oil, grease, and other flammable materials, including flammable liquids and solvents.

2. Adjacent work areas and the type of work being performed and the possible effect on the accident area.

3. Attitude of management towards safety programs and enforcement of rules.

4. Knowledge and experience of immediate supervision.

5. Safety instruction and training given workers.

The following specific information is necessary and required in a report of an accident investigation:

1. Date and time of accident.

2. Location of accident, including name, address, and responsible persons of customer.

3. Name and address of the responsible sales activity or source of the equipment.

4. Equipment involved, including serial numbers, manufacturer's name and address, date of purchase, repair or installation, and extent of damage.

5. Personnel involved, including names and addresses, nature and extent of injuries, and medical attention received.

6. Events, circumstances, or conditions just prior to or leading up to the accident. Include service history and maintenance information of equipment.

7. Description of the accident.

8. Analysis by an independent laboratory of any gases, if possible, associated with the accident.

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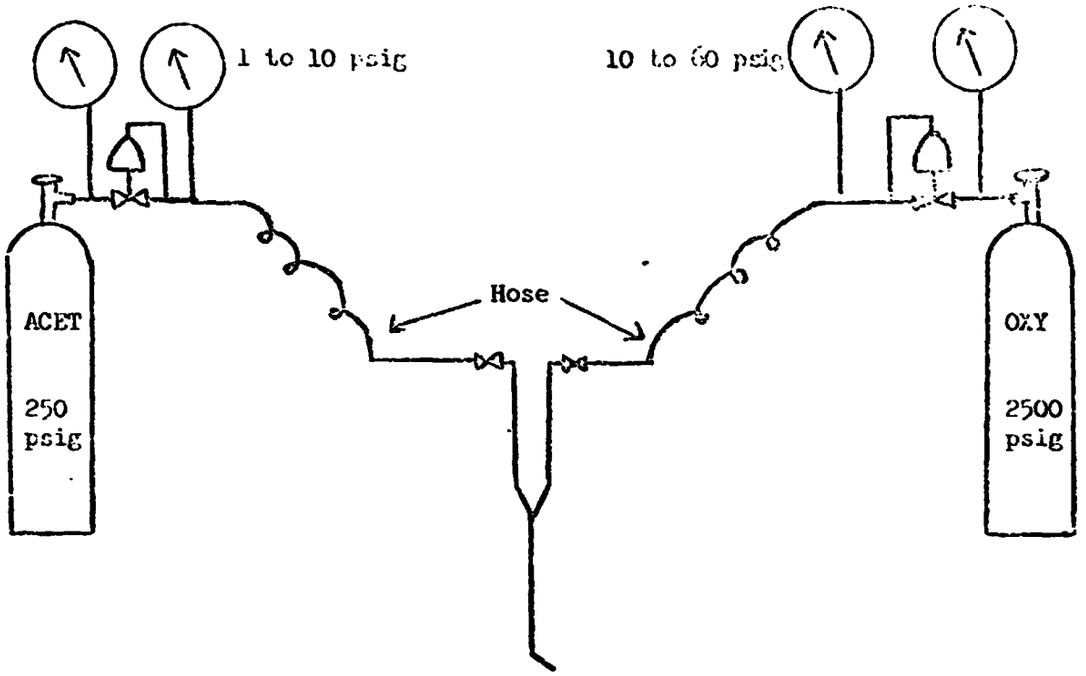
9. Obtain, if possible, statements of witnesses to or persons involved or associated with the accident.

10. Obtain photographs of equipment damaged or, if possible, return damaged equipment for thorough examination.

A basic welding or cutting outfit consists of a fuel supply cylinder, an oxygen supply cylinder, a fuel regulator, an oxygen regulator, interconnecting hose, and a cutting or welding torch. The regulators reduce the supply pressure to a usable pressure and deliver the regulated pressure through individual hoses to the torch. The fuel gas and the oxygen gas are united in correct proportion in the torch for controlled heat necessary to perform its function.

A description of the regulator and torch components of an outfit will lead to an understanding of its operation, design, and safety consideration. Acetylene is considered as the fuel gas for this discussion.

The following line diagram or flow chart shows the relationship of the various components to each other. Of particular interest is the possibility, through a sequence of misoperation, of having acetylene enter the oxygen system through the torch and form a flammable mixture. This condition usually develops when the outfit is not in operation and with all valves set ready for service. It would be necessary for both torch valves to be leaking and the oxygen regulated pressure to be at a lower pressure value than the acetylene regulated pressure. The torch tip must be obstructed or of a small enough size so as not to vent the total leakage. If the total pressure in the oxygen supply cylinder is also lower than the regulated acetylene pressure, the acetylene will transfill



to the oxygen cylinder. Under reverse conditions, the oxygen can flow to the acetylene side of the system.

Correction of this possible source of flammable mixture can be controlled by adding a check valve on the hose connection ends of the torch. Any reverse flow of gases will activate the check valves and minimize the chances of a flammable mixture forming.

This condition can also be corrected by correct operating instructions. The possibility of flammable mixture formation is lessened if the equipment is in good state of repair.

REGULATORS

Regulators are the devices used to reduce the high pressure supply gas to a lower use pressure. This is accomplished by the action of springs upon diaphragms and seats. A means is provided to adjust the spring compression manually so that the outlet pressure may be varied to meet the pressure

requirements of the application. Regulators generally are designed to make the pressure reduction in either one or two stages. The direction of pressure action on the seat may be direct or inverse, or a combination of both in two-stage regulators. All regulators have the same items in common--high and low pressure gauges, seats, nozzles, springs, diaphragms, adjusting screws, bodies, high and low pressure covers, and various safety devices to prevent overpressurization in areas of the regulator. The arrangement of these items varies with the design by different manufacturers. The inlet connections to regulators are different for the different gases handled and are generally in agreement with CGA standards and American Standard regulators. The purpose of this approach is to prevent connecting a regulator to an incorrect compressed gas supply. Generally, fuel gas regulators have left-hand connections while oxidants and inert gas regulators have right-hand connections. A standard has been established which states the oxygen connection may not be used for any other type gas to avoid the possibility of serious and violent reactions. The outlet connections are right-handed for oxygen and left-handed for fuel. Hoses and torches are provided with similar connections.

A. The following illustration is of an inverse type, single-stage regulator, that is, the inlet high pressure gas acts to close the valve assembly rather than to open the valve assembly. When the adjusting screw is backed outward to relieve the compression in the adjusting spring, high pressure from the supply exerts its force on the valve assembly and closes the valve. Placing compression on the spring with the adjusting screw forces the diaphragm toward the high-pressure side and transmits its movement to the pin which raises the valve from the seat and allows gas to flow. If a valve is placed on the outlet side of the regulator

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and closed, pressure will build up on the diaphragm in the regulator until it equals the force of the adjusting spring. When the forces are equal, the high-pressure valve closes to stop the flow of gas. The forces are unbalanced again when the outlet valve is opened and flow is resumed.

Note the filter at the inlet connection to prevent dirt, scale, and other suspended particles from entering the passages of the regulator where impacting energy could cause a reaction. The filter around the seat serves the same purpose but, in addition, changes the velocity of the gas to the regulator valve to minimize friction heat and acts, as well, as a heat sink for any heat of recompression which might be present.

1. Heat of recompression is possible within the high-pressure side of the regulator, with the adjusting screw backed off (no compression on adjusting spring), when the supply cylinder valve is opened quickly. The in-rush of high-pressure gas compresses the existing gas in the regulator high-pressure passage and raises its temperature. Since the passage volume is small, and a filter is used around the seat, the heat is usually dissipated to the surrounding area and does not reach ignition temperature. It is possible, however, for small dust particles to reach ignition temperature under these conditions and initiate a fire. If ignition does take place, the seat is consumed and failure of the seat releases the full volume of the oxygen cylinder. The added oxygen rapidly raises the temperature of the surrounding regulator parts and results in an intense fire burning a channel directly through the low-pressure side and through the case. When the burn-through becomes large, the flow of oxygen cools the area and the fire in the regulator usually extinguishes itself; however,

the flow of oxygen continues feeding external areas involved in the fire. A fire of this type is generally classed as a seat-ignition fire and involves the entire regulator.

2. Heat of friction is possible when the regulator is set for service (adjusting screw set for pressure regulation) before the oxygen cylinder valve is opened. Upon opening the oxygen cylinder valve, the high-pressure gas flows immediately to the low-pressure side and through the regulator. The pressure reduction takes place at the valve and seat. The velocity of the gases in this area causes heat of friction, along with valve movement which contributes to the total heat. If the heat is sufficiently high, seat ignition takes place resulting in a reaction as described above.

3. On regulators not equipped with inlet or seat filters, dust, scale, oil, grease, etc., passing along with the high-pressure oxygen may develop sufficient energy upon impact in the passages of the regulator to cause them to reach ignition temperature. If the glowing particles lodge on the seat, seat ignition takes place with similar damage previously described. If the glowing particles pass through the seat and lodge in the low-pressure side of the regulator, burn-out occurs. If the seat is not involved, the high-pressure oxygen flow stops upon failure of the diaphragm. Usually, the heat is sufficient to damage the seat and allows the oxygen flow to continue.

4. A low-pressure side fire is also possible when a fuel mixture occurs in the system during periods of time when the equipment is idle but

all valves are set for service flow. Under circumstances of faulty torch conditions and higher acetylene pressure values than oxygen pressures, acetylene can enter and accumulate in the oxygen system through the torch. Upon lighting the torch, a back flash occurs which can propagate back to the oxygen regulator. The severity of the reaction is dependent upon concentration of the mixture. In the proper proportions, it can be explosive. On the fuel-rich mixtures, the low-pressure side of the regulator will be involved in a fire. On fuel-lean mixtures, fire may not be involved and, therefore, little or no damage to the regulator occurs.

If the oxygen supply cylinder is at a lower value than the regulated acetylene pressure, and under the same conditions as listed above, acetylene may possibly be transfilled into the oxygen cylinder. Under these conditions, a reaction may propagate back through the regulator and into the cylinder.

When the oxygen regulator is removed from the cylinder and still remains in service setting, it is possible for acetylene to back-flow through the regulator to the atmosphere. Upon reconnecting the oxygen regulator to a cylinder of oxygen, a reaction is possible when the oxygen cylinder valve is opened. The severity of the reaction is dependent upon the concentration of the flammable mixture.

5. As a result, instructions to minimize the above have become part of the safety considerations for the operation of oxy-acetylene equipment. The important rules directly related are restated below:

a. Never stand in front of a regulator when adjusting pressures or opening supply cylinder valves.

b. Always open oxygen cylinder or high-pressure cylinder valves slowly.

c. Examine regulator inlet and outlet connections for oil, grease, and other contamination before making connections. The cylinder valve outlets should be similarly examined.

d. After use pressure has been established at the regulators and before lighting the torch, vent each gas separately from the equipment through the torch valves to remove any flammable mixture which might be present.

e. Always close all valves, release regulator adjusting screws, and vent the equipment when discontinuing welding operations.

B. The following illustration is of a two-stage regulator. The reduction of supply pressure to use pressure in two steps provides better flow characteristics at the use pressure and is preferred in heavy use applications. Pressure from the supply source acts directly on the seat in the high pressure side and on the valve in the low pressure side of the regulator.

The first stage of reduction is controlled at a preset value (usually about 250 psig) by the tension of the high pressure spring. The high pressure seat is normally open until the supply pressure exerts its force against the diaphragm and the high pressure spring. When this happens, the

compensating spring moves the lever arm and closes the seat. Upon turning the adjusting screw and compressing the low pressure spring, gas flows from the intermediate area through the low side and out the regulator.

At the same time the flow starts from the intermediate side, the high pressure spring tension is eased, causing the high pressure seat to open and allow more supply pressure to enter the regulator. The low pressure is the adjustable pressure in this regulator and the means of adjustment is the change of compression in the low pressure spring transmitting force against the diaphragm and to the valve through the valve pin in a similar method as described for the single-stage regulator.

Fire reactions involving heat of compression, friction, impact, and oxygen-fuel mixture can occur in a two-stage regulator, as well as a single-stage regulator. The type of regulator does not change the potential hazards involved.

TORCHES

Torches are the apparatus used to unite the regulated oxygen and acetylene (fuel) gases to form a flammable mixture which is capable when ignited of obtaining temperatures as high as approximately 6300° F. At these temperatures, metal may be cut (burned) or welded.

Torch design is different for metal welding and cutting operations. The welding torch consists of separate shut-off valve for oxygen and fuel gas, tubes to carry the gases to a mixer, and single-holed welding tip, all conveniently assembled into a handle. The cutting torch has an additional

shut-off valve and tube for carrying a separate oxygen stream for the cutting operation and a multi-holed cutting tip. The mixing of the gases occurs in the mixer of the welding torch and in the head of the cutting torch.

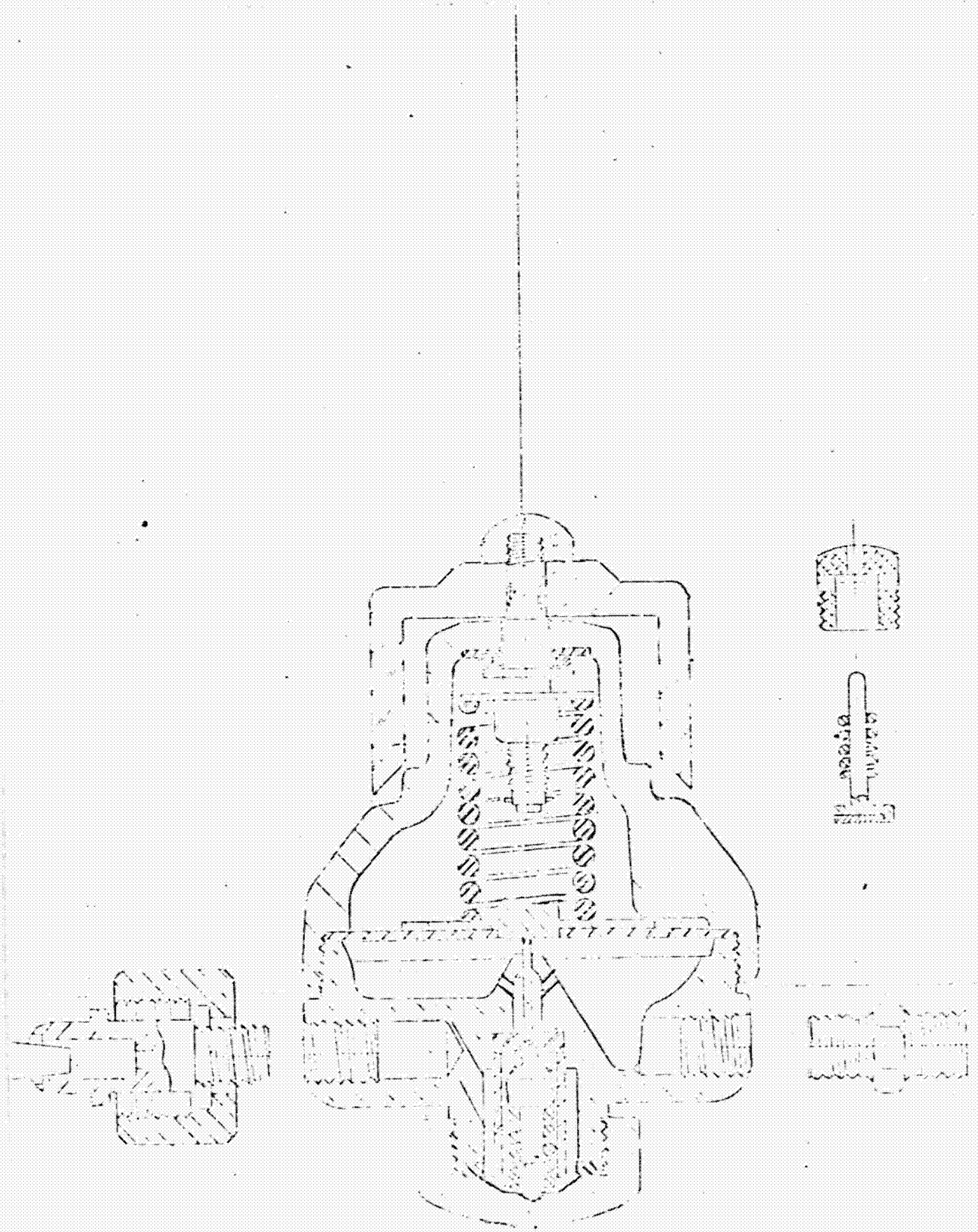
Various sizes of welding tips and cutting tips are used when working with different thickness metal. The regulated pressures of both gases vary with the tip size used. Convenient charts are supplied by the equipment manufacturers and welding societies and list the correct tip sizes and gas pressures to be used with various thickness metals.

There are several recognized hazards associated with the use of torches--backfire and flashback. A backfire is a momentary retrogression of the flame back into the tip, resulting in extinguishment of the flame. The principle cause of the backfire is operation of the torch with incorrect gas pressures (usually insufficient pressures) and low flows which allow the flame to propagate backward into the tip. A flashback is a retrogression of the flame back into the tip or mixer without the extinguishment of the flame. It is accompanied by a hissing and squealing sound and a characteristic smokey, sharp-pointed flame. Extensive damage can be done to the torch and tip if the gas flows are not immediately discontinued. A flashback is caused by insufficient gas pressures and flows and by allowing the tip to become hot enough to ignite the mixture before it leaves the tip.

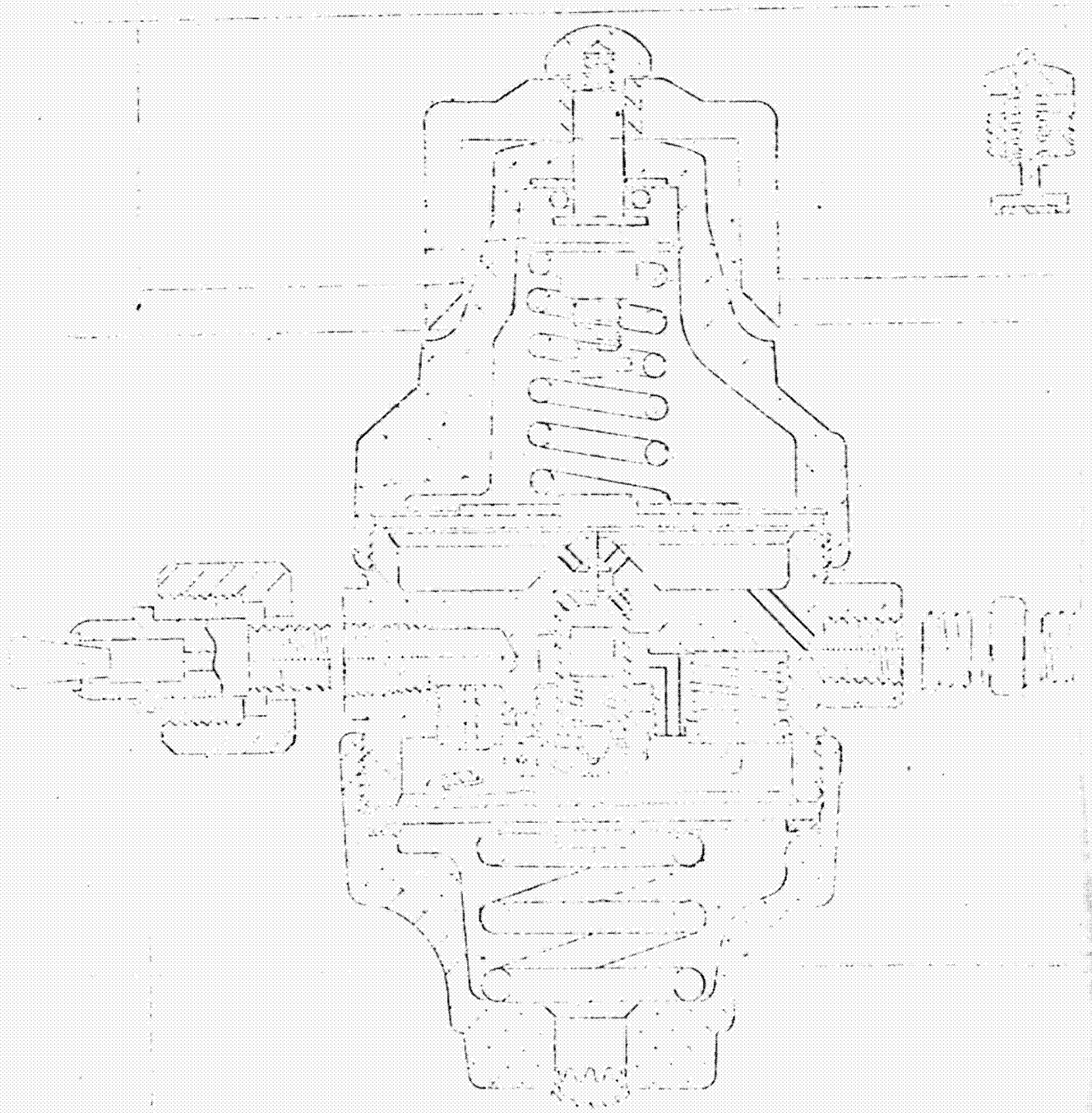
Operating a torch with faulty valves, improperly tightened mixers and tips may lead to small fires at the various leakage points. A torch in this condition, particularly with leaking shut-off valves, during periods when not in operation may permit an intermixing of gases within the connecting hoses. If the torch

is lighted without first purging the hoses of a possible mixture by alternately opening and then closing each torch shut-off valve, flame propagation may flash back to the regulator and cause extensive damage.

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Air Products and Chemicals, Inc.

SAFE HANDLING OF COMPRESSED GASES

by

Compressed Gas Association

CGA Pamphlet P-1, 10P, 1965

APCI DOCUMENT
NO. 99000277

Air Products and Chemicals INC.

SAFETY IN WELDING AN[illegible]UTTING

by

American Welding Society

USAS-249.1, 49P, 1967

APCI DOCUMENT
NO. 9900002172

Air Products and Chemicals INC.

Put It In Writing

DATE February 27, 1970

TO All Plant Managers SUBJECT Oxygen Flow Meter Ring Seal Fluid

FROM H. H. Master

cc: W. L. Ball
T. W. Blankenship
M. H. Halsted
G. G. Handley
J. M. Norwood
R. D. Paige
W. M. Say
W. J. Scharle
H. E. Wynn

Our Sparrows Point facility recently almost got into trouble on a Hagan oxygen meter. A recharge of ring seal fluid had been ordered using Hagan Specifications which called for Alkazene, Part No. RB-176. Tom Blankenship and Stu Vosburg were alert enough to check this out and found Alkazene is not compatible with oxygen.

Hagan was contacted and confirmed that the parts list was in error and our particular meter was supplied with Kel-F which is oxygen compatible. Kel-F is no longer available and future charges should be Halocarbon 4-11E (E indicates oxygen compatible corrosion inhibitor) which has a specific gravity of 1.85.

The following action shall be taken immediately:

1. All oxygen meters of doubtful fluids shall be checked immediately. Generally meters with more than 40 "H20 pressure drop across the orifice will have mercury fluid which is permissable.

2. Check all vendors literature. If Alkazene is mentioned delete it and fill it in properly.

3. Check plant stock for Alkazene and discard if it is in the facility. If for any reason it is needed elsewhere on a meter not in oxygen service, label it as not to be used on oxygen meters.

4. Post a note on the inside of the oxygen meter instrument case indicating fluid to be used in the ring.

5. With changes of fluid it will be necessary to request services of a Hagan man on pay meters for recalibration on the instrument.

ORIGINAL SIGNED BY

H. H. Master

HHM:lc
(Retyped September 20, 1972, cju)

APCI DOCUMENT NO. 99000223

Air Products and Chemicals INC

PUT IT IN WRITING

DATE June 28, 1961

TO F. Kitson (5) SUBJECT Tests of Pressure Gages Safety

FROM E. Kehat Devices -- 87-0-3820

cc: Geist, J. M.
McKinley, C.

INTRODUCTION

The object of the experimental work was to test the two modifications proposed by the Safety Department for installed pressure gages. These modifications are a restricting orifice at the inlet of the gage and a blow out plug in the gage casing.

EXPERIMENTAL

Four "used" gages were provided by the Safety Department, all four were made by the U. S. Gauge Co.

1. 0-5000 psig. 4-1/2" dial. Back connection. Plastic front. Two 3/4" rubber relief plugs in the case. This was the only gage on the list with a fully threaded front flange.

2,3. 0-3000 psig. 4-1/2" dial. Bottom connection. Plastic front. No safety relief plugs. 1" safety relief plugs were installed in these gages.

4. 0-10000 psig. 6" dial. Bottom connection. Glass front. No original safety relief plug. 1" safety relief plug was installed in the gage. The gage inlet contained a threaded plug with a 0.018" orifice.

The flanges on the last three gages were secured by two screws in open slots.

The Safety Department also provided adapters that contained 3/8" long capillaries. A & B were made from capilliary stainless steel, about 0.007" in diameter. C & D were specified at 0.0135" but when measured turned out to be 0.0225" in diameter.

The four gages were stripped of the mechanism and dial plate. The bourdon tube was opened at its tip and was thoroughly cleaned. Simulation of bourdon tube failure was made by relief devices soldered to the tip of the bourdon tube. These devices were adapted from used cylinder valves. Rupture discs, frangible type, with a bursting

APCI DOCUMENT NO. 99000224

pressure of 1400-1600 psig were used. The gages were tested in the recently constructed ignition testing cell. A short (2') length of 1/4" line connected the gage undergoing tests to a full nitrogen cylinder outside the cell. A 4000 psig, cylinder pressure gage, was connected to this line.

Surges were applied by fast opening and closing the cylinder valve. Steady pressure was applied by opening the cylinder valve and keeping it open, usually until the rupture disc burst.

RESULTS

Test No.

1. Gage No. 1. Capillary A. Steady pressure: after 3 seconds rupture disc burst and the rubber plugs blew off at the same time providing adequate relief.

2. Gage No. 1. Capillary A. (a) 1/2 second surge: no reaction. (b) Steady pressure: after 2-3 seconds rupture disc burst and the rubber plugs blew off.

3. Gage No. 1. Capillary C. At steady pressure build up to 1700 psig in five seconds. Rupture disc burst and rubber plugs blew out at the same time.

4. Gage No. 1. No Capillary. At steady pressure, pressure built up to 1500 psig in two seconds when rupture disc burst. The rubber plugs were inadvertently forgotten. A much sharper noise was heard this time than in the previous tests, indicating that the noise was masked by the sound of the rubber plugs popping off in the previous tests.

5. Gage No. 1. No capillary. Disc and plugs blew at 1600 psig. Only the sound of the plugs blowing off was heard.

6. Gage No. 2. Capillary B. Surges at 800, 1500, 1800, 2000 psig failed to rupture the disc. Fifteen seconds of steady pressure failed to rupture disc. The pressure was bled off. Line pressure built up to 500 psig from back flow from the gage. Examination of disc showed a considerable bulge but no rupture.

7. Gage No. 2. Capillary B. Steady pressure at 2200 psig line pressure. After approximately five minutes rupture disc burst. Rubber plug and plastic window blew off.

8. Gage No. 3. Capillary D. Surges at 600, 1000, 1400, 1800, and 2000 psig (in line) did not rupture disc. Steady pressure: after 5 seconds disc burst, blowing off safety plugs and gage window.

9. Gage No. 4. Internal orifice. Steady pressure: after less than one second, rupture disc burst at 1600 psig in line, glass window blew off and broke.

10. Gage No. 4. Plastic window was substituted and flange was held by three screws in holes instead of the slots that allowed movement of the flange under pressure. Steady pressure: rupture disc burst at 1800 psig in line. Rubber plug blew. Window did not blow off.

11. Gage No. 4. No rupture disc. Cylinder was provided with a pressure regulator. Surges up to 100 psig did not blow off the rubber plug. Considerable leakage from the flange and body holes was observed.

DISCUSSION OF THE RESULTS

The difference between the gages was more than the difference in the safety devices. The internal capillary on Gage 4 was as effective as the tested capillaries, in restricting flow. Capillary D on Gage 3 delayed the bursting of the rupture disc more than the similar capillary C on Gage 4. Capillary B on Gage 2 was too restrictive and will probably considerably increase the response lag on gages. It would also be too sensitive to minute amounts of dirt in the system. In this pressure range a 1" hole in the gage casing gave adequate relief even without a capillary restriction. For higher pressures a restriction would probably be more useful.

The maximum discharge through an orifice for air is:

(1) $W = 0.533 \frac{C_v S P}{\sqrt{T}}$ (Perry. p. 403)

where W = flow rate lb/sec.

C_v = 0.61 for a sharp edged orifice

$S = \frac{\pi}{4} \times 1^2 = 0.78$ sq. in.

T = 540°R; $\sqrt{T} = 23.2$

P = max. desired pressure in casing = 150 psig.

W = 2.1 lb/sec.

At 3000 psig approximate maximum air flow rate through an oversized bourdon tube 0.4" i.d. can be calculated from the equation 1, assuming a contraction ratio of 5 between pipe-bourdon diameters.

Here $S = \frac{\pi}{4} \times 0.4^2 = 0.126 \text{ in}^2$

and $P = 3000$ psig

$W = 8.7$ lb/sec. more than the capacity of the relief hole in the casing.

The approximate maximum size of restriction that will prevent pressure build up of more than 150 psig in the casing can be calculated from the relation (2).

(2) $D_1^2 P_1 = D_2^2 P_2$ derived from equation 1.

where D_1 = casing hole diameter - 1"

D_2 = max. size of restriction

P_1 = casing pressure - 150 psig

P_2 = line pressure - 3000 psig

$$D_2^2 = \frac{P_1}{P_2} 1^2 = \frac{150}{3000} \times 1^2 = 0.05$$

$D_2 = 0.22$"

A restrictive .0225" will give adequate protection with a considerable safety factor, without increasing the response time of the gage.

CONCLUSIONS

1. A restrictive capillary .0225" in diameter in combination with a 1" hole in the casing will give adequate protection for bourdon tube rupture.

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2. Gage front flanges should have a stronger fastener to the casing than the screw in slot type of fastener, and preferably be fully threaded.

ORIGINAL SIGNED BY

E. Kehat

EK:faj

(Retyped September 26, 1972, cju)

Air Products and Chemicals INC.

PUT IT IN WRITING

Date: August 2, 1961

TO: Distribution

Subject: Summary of Action Taken on Pressure Gauges

FROM: F. K. Kitson - Safety Department

Following an accident at Granite City which resulted in injuries to two personnel when a pressure gauge bourdon tube ruptured, pressure gauge specifications and existing pressure gauges have been reviewed to determine what action is necessary to provide adequate safety features in the gauges. The results of this survey are listed below to inform the distribution of the corrective action to be taken on existing gauges.

A. Four and one-half Inch Gauges and Larger

1. All gauges being purchased will comply with existing standards i.e. plastic crystals, solid fronts and complete blowout backs on all ranges of positive or vacuum gauges. Gauges supplied with vendors' packaged equipment will be required to meet the above standards. Any deviations must be obtained from the Safety Department in the event that special gauges are required which do not comply with the standards.

2. All existing gauges shall be modified as follows:

   a. All existing gauges, regardless of pressure, shall be provided with plastic crystals. Safety glass is not considered an acceptable substitute.

   b. A restrictive orifice shall be installed on the gauge socket and blowout plug (grommet) shall be provided in the gauge casing as shown below:

Range	Restrictive Orifice	Blowout Plug (Minimum)
0-100 PSIG & Vacuum	None	3/4"
0-500	None	1"
0-1,000	.05"	1"
0-5,000	.05"	(2) 3/4"
0-10,000	.05"	(2) 1"

NOTE: Blowout plugs may be obtained from Manning, Maxwell, and Moore, Stratford, Connecticut. It is possible the Spare Parts Department will stock the plugs at a future date. It is anticipated that the restrictive orifices will be stocked by the Spare Parts Department in the near future.

Gauge sockets should be examined carefully to determine if a restrictive orifice has been provided by the manufacturer.

APCI DOCUMENT NO. 99000275

The below listed precautions should be observed while reworking gauges:

(1) All gauges shall be removed from service when drilling casing for blowout plug.

(2) Blowout plugs shall be tested for ease of release. After drilling hole for blowout plug, knock off burrs from inside of casing,

(3) Blowout plugs shall be located such that clearance is provided for the plug to relieve.

c. All crystal retainer covers which are held on the gauge case by screws in slots shall be drilled and secured with metal threading screws.

d. All manifold gauges in cylinder filling rooms should be located above eye level; a height of six feet four inches above the floor level is suggested to standardize where possible.

e. All test gauges for cylinder filling shall have a minimum range of 4,000 psi for existing gauges, or 5,000 as required by recent standard for purchasing gauges.

B. Two Inch to Three and one-half Inch Instrument Transmitter Output Gauges and Three and one-half Inch Main Panel Board Indicating Controller Gauges.

The maximum pressure that can be admitted to these gauges is the output of the instrument compressor, approximately 100 psig. This pressure could damage the bourdon tube to make the gauge inoperative but a safety factor is provided to prevent rupture. Therefore, these gauges are acceptable as manufactured.

C. One and one-half Inch to Two and one-half Inch Gauges

1. K-G welding gauges (above 1,000 psi) are approved by the Underwriters' Laboratories and have restricting orifice on the inlet to the bourdon tube in addition to a pressure relieving area at the point of entry on the gauge socket into the casing. These gauges are therefore approved as fabricated.

2. U. S. Gauges under 1,000 psi have been tested and on the basis of these tests are approved.

3. Gauges in this category which are not included under Item No. 1 or 2 above will be evaluated individually to determine what action is necessary. The quantity of gauges in this category represent a very small percentage of the total number of existing gauges and therefore should not present a problem in an individual review.

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D. Full Case Recorders with Full Process Pressure Piped Inside the Case (Pressure Recorders and Controllers)

All recorder window crystals shall be plastic. Safety glass is not considered an acceptable substitute.

If there is any question as to the course of action to be taken in connection with modifications of existing gauges, please contact the writer.

ORIGINAL SIGNED BY

F. K. Kitson

FKK:jmf

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D. E. Cummings
W. R. Decker
K. G. Dieker
A. M. Gehringer
R. E. Greenburg
E. H. Griffith
R. E. Hill
M. R. Hillegass
J. R. Johnston
E. R. McRedmond
R. W. Metzger
A. L. Miller
J. J. Mittleman
E. W. Renner
E. E. Rosser
W. N. Salminen
C. W. Steel
J. K. Stewart (6)
R. D. Terrill
B. J. Tesmer

OPERATIONS

M. H. Hubbs
H. W. Keys
H. H. Master
J. R. McLonald (4)
W. M. Say (15)
R. K. Wetherhold
B. F. Wobker
H. E. Wynn (10)

R & D

R. H. Foster
C. McKinley

STANDARDS

H. W. Farrow

MANUFACTURING

D. R. Besecker
M. E. Billig
G. J. Hartnett
C. R. Pattison
H. D. Woodeshick

SPARE PARTS

J. G. Brandt
R. H. Caligiuri

ENGINEERING

G. W. Bretz (15)
R. W. Campbell (3)
F. B. Eastman (30)
E. P. Thomas (2)
L. L. Volland (6)

K-G

S. E. Fey
G. A. Rubens

DEFENSE AND SPACE

K. Zietz (6)

CC: C. R. Anderson
J. L. Cost
E. J. Douley
M. H. Halsted
G. F. Pool
L. P. Pool

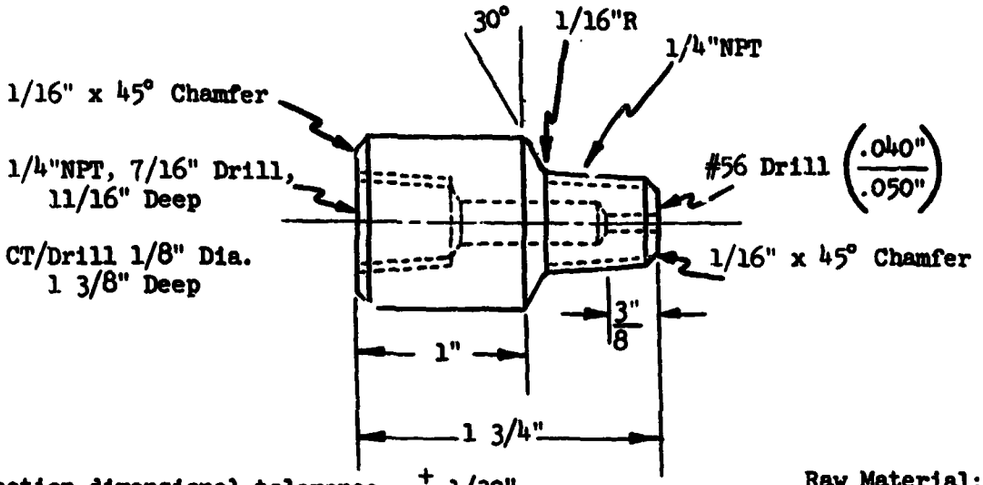
(Retyped 9/26/72 sba)

DESIGN ENGINEERING STANDARDS

530 INSTRUMENTATION

PRESSURE GAUGE SNUBBER

PART NO. 1 Snubber, Pressure Gage, Range 800 psi and lower, 1/4" MNPT.
Code Control No. 3-792-05-0001.

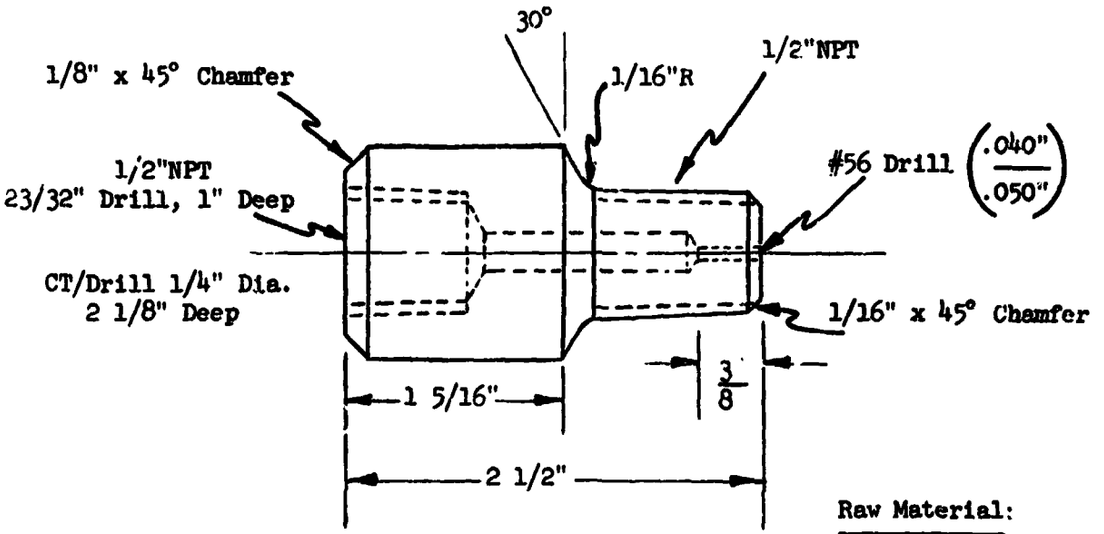


Fraction dimensional tolerance = ± 1/32"

Raw Material:
BAR HEX NAV BRS B21-A 1"

Material Code No.
1-126-05-0029

PART NO. 2 Snubber, Pressure Gage, Range 1,000 psi up to 10,000 psi, 1/2" MNPT.
Code Control No. 3-792-69-0001.



Raw Material:
BAR HEX STSTL 304 1 1/2"

Material Code No.
1-112-69-0023

Fraction dimensional tolerance = ± 1/32"

Air Products and Chemicals

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Date
12-5-61

Air Products and Chemicals INC.

PUT IT IN WRITING

Date: January 19, 1971

TO: Distribution

Subject: Nash Vacuum Pumps

FROM: F. K. Kitson

Distribution:
A. Arseneaux - New Orleans
P. Bunnell - Iselin
F. E. Cody - La Porte
J. Conville - Boston
R. Everson - Chicago
D. Harris - Middletown
P. Kmetz - Camden
L. Lidolph - South Bend
R. McVicker - Rochester
S. Myers - Memphis
H. Noffke - Kansas City
A. Pope - Bladensburg
J. Seier - Omaha
B. Winters - Muscle Shoals

cc: IGD Regional Engineers
M. R. Hillegass
P. F. Newman
G. A. Timberlake

Due to problems encountered in water carry-over into cylinders from Nash vacuum pump systems, the attached IGD sketch #1112, Rev. 12/28/70, has been prepared for each facility provided with a Nash vacuum pump to modify the vacuum piping system and completely eliminate the possibility of water carry-over. In addition to the potentially serious problem of water entering medical cylinders, particularly "D's" and "E's", our Special Permit #4779 for visual inspection of cylinders is based on maintaining the cylinders dry and filling with a dry gas.

Please advise me when the vacuum system has been modified to comply with the attached sketch.

ORIGINAL SIGNED BY

F. K. Kitson

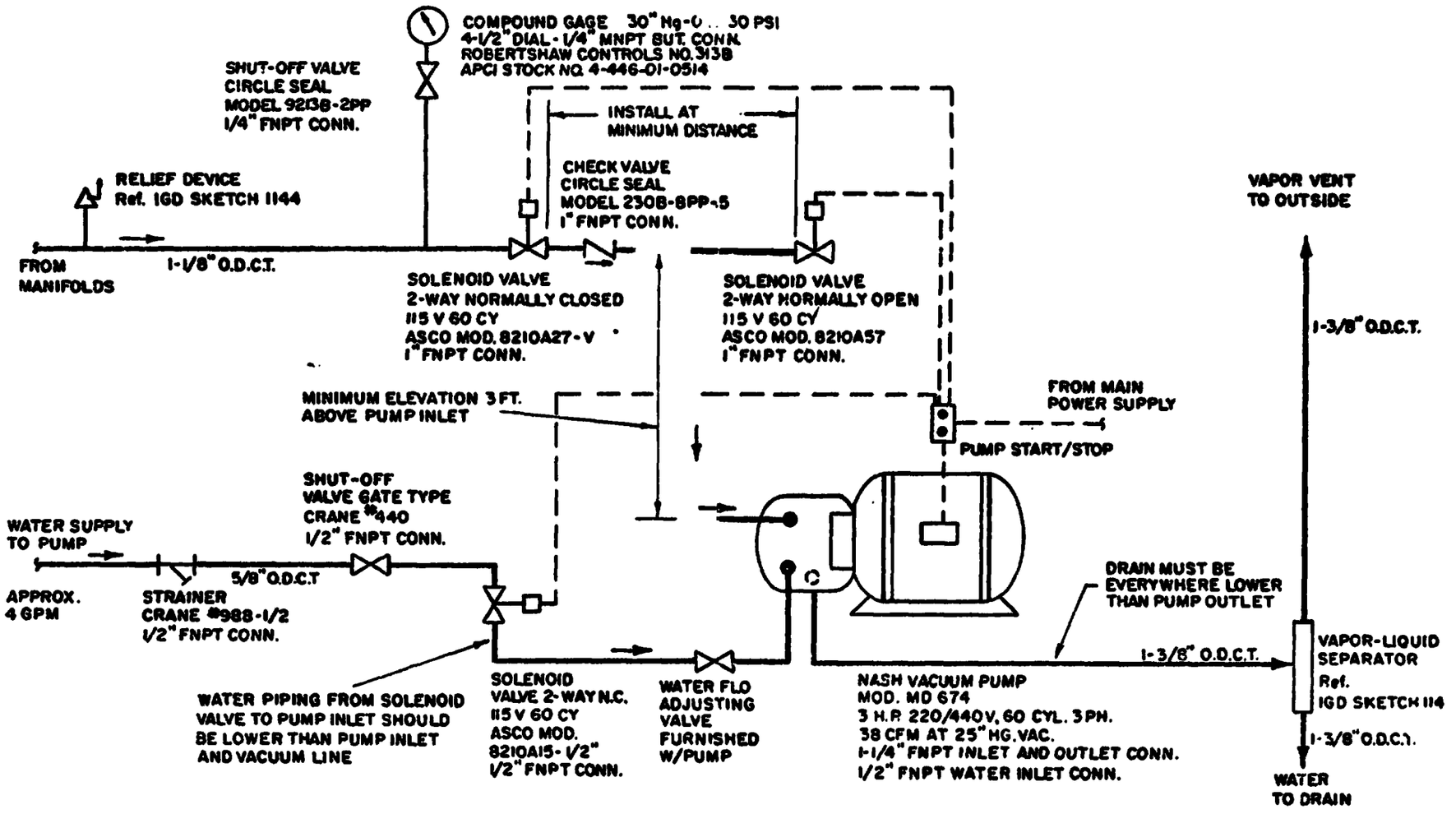
FKK:nb

Attachment

6

(Retyped 9/26/72 sba)

APCI DOCUMENT NO. 99002276



NOTE:
WIRE SOLENOID VALVES TO OPEN OR CLOSE AS INDICATED
WHEN VACUUM PUMP MOTOR OPERATES

TYPICAL PIPING ARRANGEMENT
for all NASH VACUUM PUMP INSTALLATIONS
at IGD CYLINDER FILLING FACILITIES

Air Products and Chemicals INC.
ALLENTOWN, PENNSYLVANIA, U. S. A.

IGD SKETCH #1112

Rev. 2/28/69, 12/16/69
Rev. 1/31/69
Rev. 6/3/69

W. L. Ent
H. Wynn

December 15, 1967

W. L. Ball

Hose Connector Accident - Granite City

cc: L. R. Mann
H. H. Master

An incident that occurred this past week at Granite City again points up the undesirability of using a hammer on the liquid transfer hose lugs to insure a tight coupling. A brass hammer was being used at Granite City to pound the lugs to accomplish the final tightening. A chip was knocked from the edge of the hammer and shattered the left lens of the loader's safety glasses. The impact of the chip was sufficient to poke a hole in the center of the lens as well as to dislodge the inner corner of the lens from the frame. Undoubtedly blindness would have occurred if the man had not been wearing safety glasses. The field reports that flying chips from the hammer used in this manner are not uncommon, and a visual inspection of the hammer in question indicates the validity of this contention.

The use of a wrench that originally was designed at Creighton (I believe by Phil Elson) will accomplish several objectives:

1. Although the wrench utilizes the lugs on the hose connector, the lugs will not be deformed to any great degree.

2. Being designed as an impact wrench, a suitable hammer can be used which will help to eliminate the possibility of flying chips.

3. As reported by the people at Ashland, with frequent changes of gaskets, using the wrench to hand tightness gives sufficient tightness to avoid leakage, thus eliminating the use of the manner altogether.

It is therefore recommended:

1. That wrenches be supplied at all loading facilities, and suitable hammers be provided in the event their usage is necessary to avoid leakage.

2. The usage of the hammer of the type used at Granite City be investigated immediately, as it appears that the metal is too brittle for such service. The hammer is identified by the words "AMPCO H-14".

Original Signed By

W. L. Ball

WLB:dt

Re-typed June 5, 1972
kfq

APCI DOCUMENT NO. 99000272

AIR PRODUCTS AND CHEMICALS, INC.

Date December 15, 1967

To See Distribution Subject Near Miss Accident -

From M. H. Hubbs Granite City Facility

Distribution: Allegheny-Midwestern Region Plant Managers
Eastern Region Plant Managers

cc: W. L. Ball
D. L. Fox
M. H. Halsted
A. L. Hatley
F. A. Iobst
H. H. Master
G. C. Misus
J. L. Stief
W. T. Straughan

Generally, a letter or a memo from this office brings bad news.

We are most happy to report that Fred Reed of the Granite City Facility had the sight in his left eye saved because he was wearing his safety glasses.

Fred was using a brass hammer to tighten a transfer hose fitting on the rear of a trailer. A piece of the metal from the hammer broke off striking the left lens of his safety glasses. Needless to say, the left lens was shattered. Fred was not injured. This could very well be one of the best Christmas presents Fred will receive.

We strongly urge you to post this letter on the bulletin board for all employees to read.

We will distribute the goggles worn by Fred to each plant where they may be displayed for a short period of time.

We are applying to the Wise Owl Club of America for the appropriate certificate of membership for the employee.

ORIGINAL SIGNED BY

M. H. Hubbs

MHH:ch

(Retyped 9/26/72 db)

3CI DOCUMENT NO. 22000228

Air Products and Chemicals INC

PUT IT IN WRITING

Date: February 8, 1971

TO: Distribution

Subject: Near Miss

FROM: H. H. Master

Burns Harbor

Distribution: W. L. Ball
W. K. Corey
M. H. Halsted
F. A. Iobst
F. K. Kitson
W. J. Scharle
H. E. Wynn

On 2/5/71 at approximately 2:30 p.m. the Burns Harbor facility had a near miss incident in the loading area.

A new assistant operator, K. Gumz (hired 12/9/70), was working with operator R. Short on loading LOX tanker, number 5007. When it was almost full R. Short left the area to check on the hydrogen plant and when he passed the front of the tractor he removed the flags. He intended to return almost immediately to the area.

In the meantime K. Gumz proceeded to hook up trailer 3923 and the driver approached 5007 with intentions of pulling away. He waved to K. Gumz and asked if it was ready. K. Gumz waved back but stated he did not hear the driver say anything. Apparently the wave was presumed by the driver as an approval on pulling away and the loader only intended it as a greeting.

The driver started to pull out and K. Gumz ran forward and managed to stop him. The line was still hooked up and the loading valve was open. However, the tractor was stopped before any lines were broken although the system was distorted about 15" from the normal position.

Fault was actually with all individuals involved. The flag should not have been removed before the line was disconnected. The loader should have had positive agreement with the driver. The driver should have made a complete circuit of the unit before pulling away.

The old Fleet Safety Manual states, "Prior to starting the tractor engine the driver shall make a complete circuit of the trailer to insure the transfer line is disconnected, electric grounds removed, wheel chocks removed and stored in proper location and compartment doors closed and latched. Note: Failure to disconnect a transfer hose prior to moving a trailer shall be considered a serious infraction of safety."

The new Fleet Safety Manual states, "Note: When loading liquid trailers, failing to disconnect fill hose when driving away from loading station

APCI DOCUMENT NO 9100229

Air Products and Chemicals INC.

is cause for disciplinary action."

POM 1.17 states, "A warning flag on a stand is to be kept in front of the tractor or trailer as long as the transfer hose and electrical ground are connected to the trailer. Before moving from the loading point, the equipment must be circled to ensure that all is clear and hose is disconnected. The flag can then be removed, and the trailer pulled from the spot."

W. Corey is giving Operations personnel involved a verbal reprimand. Drivers are now to put keys in loading shanty so they must check with the loader before leaving.

ORIGINAL SIGNED BY

H. H. Master

HHM:dka

(Retyped 9/26/72 sba)

Air Products and Chemicals INC

LIQUID OXYGEN EXPLOSION

by

Manufacturing Chemists Association

MCA Case History No. 824
2P, August, 1962

APCI DOCUMENT ID 9900002820

Air Products and Chemicals INC.

PUT IT IN WRITING

Date: June 4, 1968

TO: See Distribution

Subject: Near Miss Accident - Creighton

FROM: M. H. Hubbs

Distribution: Allegheny Region Plant Managers
Eastern Region Plant Managers
Midwest Region Plant Managers
W. F. Cunningham

cc: W. L. Ball
J. H. Colby
W. L. Ent
P. A. Elson
H. H. Master
W. T. Straughan
H. E. Wynn

Attached is a report of a near miss accident which took place in the Creighton cylinder fill plant.

This information is to be used in one of your future safety meetings.

ORIGINAL SIGNED BY

M. H. Hubbs

MHH:c

Attachment

APCI DOCUMENT NO. 99000281

Air Products and Chemicals INC.

NEAR MISS ACCIDENT

Creighton - May 18, 1968

May 18, 1968, on the 12:00 midnight to 8:00 a.m. shift a near miss accident took place on one of the oxygen cylinder fill racks at Creighton.

All cylinders on the rack had been filled to 2650 psig at 95°F. The Paul Pump was shut down; all block valves closed. All cylinder valves were closed except the last cylinder, No. 1 on the sketch, of one rack. The safety disc on the last cylinder ruptured before the cylinder valve could be closed.

The force of the escaping gas caused the cylinder to break loose from the pigtail and to cause the adjacent cylinder in No. 2 spot to break loose from its fill line.

Examination of the frangible disc assembly revealed the following:

1. The safety nut had several marks on it indicating it had been struck by a wrench or other object on possibly more than one occasion.

2. The end of the safety nut (No. 3 on the sketch) which blew out was not a new break. The face of the nut indicated it had been bumped. There were hairline cracks across the face (No. 3 on sketch) of the nut. When the frangible disc ruptured, the pressure completed the old break. This accounted for the thrust, the movement of the cylinder, and the pigtail breaking. The escaping gas did not diffuse through the four holes in the cap but followed the line of least resistance.

3. Examination of the safety disc indicated exposure to the elements causing discoloration. Whether corrosion was involved is unknown. Since the disc did break, it can be assumed that it was probably damaged when No. 2 above occurred.

4. The back-up washer appears to be in good condition.

Recommendation

1. As visual inspections are made of cylinders, the frangible disc assembly must be carefully examined for cracks, dents, or out of shape. When obvious damage is found, the entire frangible safety device assembly should be replaced.

MHHubbs:c

(Retyped 9/26/72 sba)

MODIFICATION TO EXISTING PRESSURE GAUGES

SNUBBER

1. PURPOSE

This standard provides the necessary data for the manufacture of a snubbing device (restrictive orifice) intended for use in the installation of pressure indicating equipment.

The snubbing device shall be installed at the inlet gauge socket to limit the volume of gas in the event of a bourdon tube rupture.

2. SCOPE

All gauges, four and one-half inch and larger, being purchased, will comply with the Design Engineering Standard: Pressure Indicators - 531.2; i.e. there shall be plastic crystals, solid fronts and blow-out backs on all ranges of positive or vacuum gauges.

3. SNUBBER

A restrictive orifice (snubber) shall be installed on the gauge socket of all existing gauges (four and one-half inch and larger) which do not comply with the existing standard.

The snubber shall be provided as shown below:

Range	Restrictive Orifice
0 - 100 Psig & Vacuum	None
0 - 500 Psig	None
0 - 1000	0.05"
0 - 5000	0.05"
0 - 10,000	0.05"

Gauge sockets should be examined to determine if a restrictive orifice has been provided by the manufacturer.

Two sizes of Restrictive Orifice Snubbing devices are covered by this standard. Part I is for pressure ranges up to and including 800 PSIG, manufactured of Stainless Steel for 1/2" NPT connections.

Part II is for pressure ranges of 1000 PSIG through to and including 10,000 PSIG, manufactured of Stainless Steel for 1/2" NPT connections.

Included as a part of this standard are the raw material and finished part Material Code Numbers which are intended to be used for the purpose of identification.

APCI DOCUMENT NO. 99000382

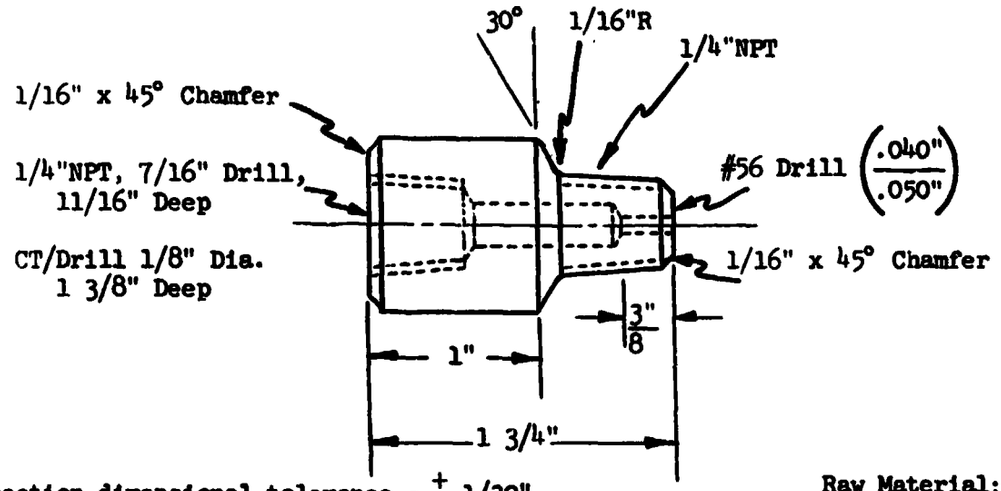
Air Products and Chemicals, Inc.

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Date 12-5-61

PRESSURE GAUGE — SNUBBER

PART NO. 1 Snubber, Pressure Gage, Range 800 psi and lower, 1/4" MNPT.
Code Control No. 3-792-05-0001.

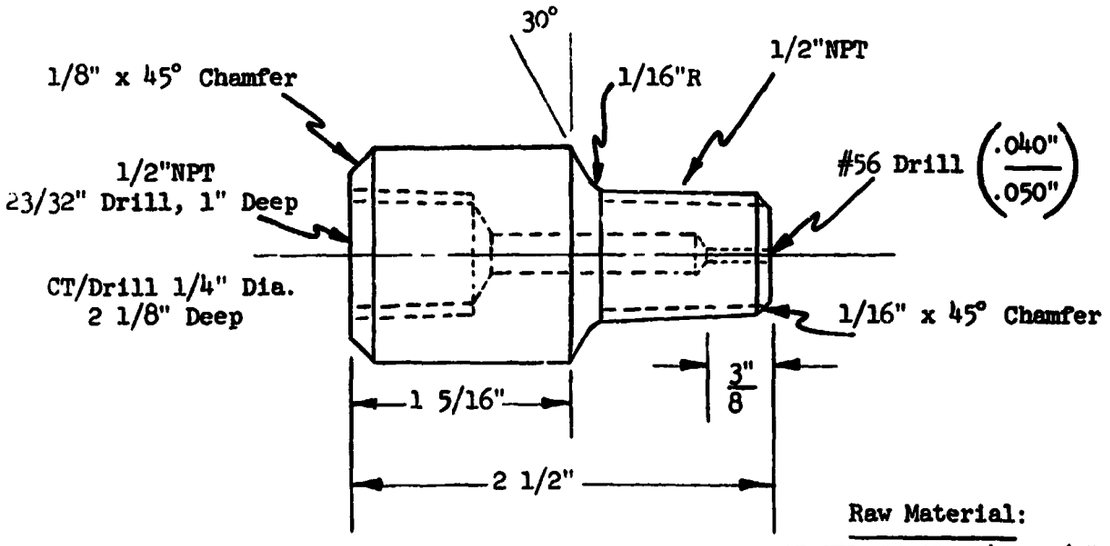


Fraction dimensional tolerance = ± 1/32"

Raw Material:
BAR HEX NAV BRS B21-A 1"

Material Code No.
1-126-05-0029

PART NO. 2 Snubber, Pressure Gage, Range 1,000 psi up to 10,000 psi, 1/2" MNPT.
Code Control No. 3-792-69-0001.



Raw Material:
BAR HEX STSTL 304 1 1/2"

Material Code No.
1-112-69-0023

Fraction dimensional tolerance = ± 1/32"

Air Products and Chemicals

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Date
12-5-61

SAFE HANDLING OF CRYOGENIC LIQUIDS AND ASSOCIATED EQUIPMENT

I. PURPOSE

To establish a standard procedure that consolidates general rules for handling and transferring cryogenic liquids and advises personnel on maintenance and safety rules that apply to various types of containers, piping, and transfer equipment.

II. RESPONSIBILITY

All APCI personnel are responsible for compliance with these procedures, for monitoring the activities of other people, and for training unfamiliar personnel in handling procedures. In those rare cases where outside personnel are required to handle cryogenic liquids, to work in storage areas, or to perform maintenance on or near storage equipment, the management personnel at the facility or field location are responsible for training these people before authorizing them to work.

III. PROCEDURE

A. General

1. Only trained persons who are familiar with the properties of cryogenic liquids shall be permitted to use and handle them. These people must be knowledgeable and skilled in the use of particular types of cryogenic liquid handling equipment. Some properties of various cryogenic liquids are outlined on pages 4 through 8 of the pocket-sized "Operations Safety Manual." More details are included in Safety Grams 51 through 55C, located in the Operations Department "Safety" binder.

2. All transfer lines, connections, tools, fittings, containers, and associated piping and equipment must be kept in good condition and replaced as necessary.

3. Transfer hoses must have dust caps in place and be stored properly when not in use.

4. The extremely cold temperatures associated with cryogenic liquids put a limit on the materials usable for this service. Ordinary carbon steels lose their ductility and are

SAFE HANDLING OF CRYOGENIC LIQUIDS
AND ASSOCIATED EQUIPMENT

considered too brittle for service at cryogenic temperatures. Some suitable materials are stainless steel, copper, copper-silicon alloys, aluminum, Monel, and some brasses and bronzes. If materials or parts similar to original equipment are not available for repairs, replacement, or modifications, or there is some question about properties of materials at low temperatures, the Operations staff offices shall be contacted for clearance or instructions.

5. Liquid-to-gas expansion ratios vary with different products. Depending on the product, volume expansions are 800 or 900 to 1 when liquid is vaporized to gas and heated to ambient temperatures. All pipelines or vessels in which liquid can be trapped must have safety relief devices to prevent overpressuring and possible rupture.

6. Warm vessels or containers being filled with cryogenic liquids shall be cooled gradually to prevent thermal shock, which could damage equipment and cause possible injury to personnel. Excessive splashing could also result from transferring liquid too rapidly.

7. Chemical goggles and approved gauntlet gloves must be worn when handling cryogenic liquids or performing transfer operations.

8. Throwing solids or liquids into cryogenic liquids for the purpose of watching the effect shall not be permitted. The violent boiling action could cause liquid to spray onto persons or equipment.

9. Prolonged breathing of cold vapors must be avoided. Serious illness can result. Some products are also asphyxiants. Precautions are explained in III, B.

10. Cryogenic liquids in contact with the skin for relatively short periods of time can cause burns. Burns will also result from extended contact with uninsulated pipes or vessels that contain cryogenic liquids.

11. In the event of thermal burns of the skin, the affected area should be flushed with copious amounts of water to reduce

SAFE HANDLING OF CRYOGENIC LIQUIDS
AND ASSOCIATED EQUIPMENT

freezing of skin tissue. The injury should be treated by a physician as soon as possible.

12. Safety valves and rupture discs shall be piped with a warmup loop sufficient to prevent water from condensing or freezing in these safety devices. Valves in outside service should be covered, have their discharges manifolded, or have pipe stubs installed in their discharge ports to prevent rain and snow from corroding or freezing internal parts, rendering the devices inoperative. Outlets piped to the atmosphere shall not discharge in areas where personnel would be subject to sprays of liquid. Oxygen safety valve discharges may not be manifolded with those from other safety valves. Oxygen entering piping that might be contaminated could result in a fire or energy release. Refer to procedure 6.02, Safety Valves and Rupture Discs, for details on these devices.

13. Steam or hot water should be used to thaw frozen equipment. Frozen valves should be thawed by directing the warming medium on the valve bonnet and on the extension below the packing nut. If steam or hot water is directed to the packing nut, the packing nut may freeze, rendering the valve inoperative.

14. A liquid transfer line shall always be drained before disconnecting it.

15. It is prohibited to hammer a hose connection during transfer. If connections leak, the transfer must be stopped and the bleed valve opened or the line drained before the fitting can be tightened.

B. Safety Considerations With Asphyxiants

1. Except for oxygen, all liquid products handled will vaporize into asphyxiating gases. The most common products are nitrogen, argon, and hydrogen. Personnel must be familiar with their properties.

2. High concentrations of escaping gas shall not be allowed to accumulate in enclosed areas. Whenever possible, work shall be done in open or sufficiently ventilated areas. If there is any doubt about the safety of the breathing

SAFE HANDLING OF CRYOGENIC LIQUIDS
AND ASSOCIATED EQUIPMENT

atmosphere in a particular area, the area shall be sampled with an approved oxygen analyzer (sniffer). No one is to enter or remain in an atmosphere containing less than 18 percent oxygen.

C. Safety Considerations with Oxygen

1. Oxygen is nontoxic and will not burn, but it does support combustion. Pure oxygen can increase combustion rates greatly or, in the case of some materials if mixed with oils or grease, can react violently when energy or an ignition source is applied to the mixture.

2. There is to be no smoking or open flames within 50 feet of oxygen loading or unloading areas or of oxygen storage tanks. Appropriate signs shall be posted. Some tank vents may not be in the immediate loading area. In such cases, the no smoking regulations apply also to vent areas.

3. Liquid oxygen shall be handled in well ventilated areas only. Personnel exposed to oxygen vapors for any length of time dare not smoke and must avoid other sources of ignition for at least one-half hour after exposure, since clothing saturated with vapors will catch fire easily. Detailed accounts of such incidents appear in a paper entitled "Too Much Oxygen" in the Operations "Safety" binder. Areas where oxygen concentration is doubtful shall be checked with an analyzer. No one is to enter areas having oxygen concentrations of 25 percent or higher.

4. Oxygen storage units may not be placed on macadam, asphalt, or any other oil base surfaces. Only concrete pads and clean gravel or stone surfaces are satisfactory. Concrete pads are most desirable.

5. Containers, piping, or any other equipment to be used in oxygen service must be checked for contamination and solvent cleaned as necessary before installation or use. Refer to procedure 1.08 for details. Tools used for installation of oxygen systems must also be solvent cleaned.

SAFE HANDLING OF CRYOGENIC LIQUIDS
AND ASSOCIATED EQUIPMENT

D. Safety Considerations with Flammables

1. The liquid of greatest concern is hydrogen. Some company operations concern hydrocarbon gases or liquefied petroleum gases as products and/or processes, but hydrogen can be considered as a typical flammable since its wide flammability range and ease of ignition require that it be handled with extreme caution. The same precautions that apply to hydrogen will generally apply to other flammable gases.

2. Adequate ventilation must be provided where hydrogen is being handled or used. This is to prevent buildup of hydrogen to explosive limits (and also to maintain breathing atmosphere of at least 18 percent oxygen).

3. There shall be no smoking, open flames, welding, or other possible sources of ignition within 50 feet of liquid storage having a capacity up to 1500 gallons. This limit shall be 75 feet when storage capacity exceeds 1500 gallons. Some tank vents may not be in the immediate storage area. In such cases, the distance limitations apply also to the vent areas. Appropriate signs shall be posted at strategic spots in these areas.

4. Only approved explosionproof electrical equipment is permitted in areas where there is flammable storage, piping, or associated equipment. No equipment shall be modified or added without Operations Department staff approval. Any work areas where the atmosphere may contain concentrations of flammable gas must be checked thoroughly before power tools or other electrical equipment can be used. Safety Work Permits are required before any work can be done in these areas.

5. If vent stack extensions are provided, they must be placed on the liquid trailers before proceeding with transfer operations. Electrical grounds shall be connected, and the hose shall be purged with nitrogen as applicable.

6. Liquid hydrogen shall not be poured from one container to another or transferred in an open system. If this is done, oxygen from the air will condense into the liquid hydrogen, presenting an explosion hazard.

7. Vehicular traffic will not be permitted adjacent to loading,

unloading, or venting operations.

E. Safety Considerations with Various Types of Cryogenic Containers

1. Dewars - These dewars are either open, nonpressurized, vacuum-jacketed vessels or closed, pressurized, vaccum-jacketed vessels used to contain cryogenic liquids. Liquid product cylinders are one type of closed, pressurized vessels. Some specific rules for dewars are:

   a. Containers must be handled carefully.

   b. Covers should be kept in place when the dewar is not being used. Moisture accumulating in the neck or on the cover can plug the container and cause rupture by over-pressurization.

   c. A cold outside jacket on the container indicates a loss of vacuum. Such containers must be removed from service and repaired.

   d. Dewars must never be filled in unventilated areas.

2. Storage Tanks - Storage tank capacities may vary from several hundred gallons to thousands of gallons of liquid. They are usually cylindrical or spherical, and normal pressures vary from atmospheric to several hundred pounds per square inch. Operators required to work with these containers, even those who must work near them as part of the workday environment, must learn the peculiarities and valving arrangements of particular installations. The following general rules apply to liquid storage tanks:

   a. With vacuum-jacketed containers, any abnormal increase in pressure in the annular space warrants immediate investigation for possible leakage of the inner or outer tank. Such leaks can cause excessive losses due to heat leakage and can raise annular space pressures to the point where safety devices could be actuated, causing powdered insulation to be discharged into the

SAFE HANDLING OF CRYOGENIC LIQUIDS
AND ASSOCIATED EQUIPMENT

storage area. Also, the tanks have carbon steel outer shells which can break at reduced temperatures releasing liquid or vapors in large areas. Bad breaks could cause excessive cooling of structural members and collapse the tank support members.

b. When tanks are located inside insulated buildings, the insulated space is purged with nitrogen, and the atmosphere must be tested weekly at various points to check for possible tank, valve bonnet, packing, or piping leaks. All frost spots must be investigated to determine if they are caused by leaks or faulty insulation. If any checks indicate oxygen concentrations above 21 percent, steps shall be taken to check for adequate nitrogen purge to increase the nitrogen purge, and to locate and repair leaks. For details, refer to procedure 1.14, Locating Leaks in Cold Boxes.

c. Oxygen storage tanks must have their contents checked weekly for acetylene. If the slightest trace of acetylene is detected, the Operations Staff office shall be notified immediately.

d. Never overfill a storage tank. At least 5 percent of vapor space must be maintained for the vessels. Consult the vendor's literature or the operating instructions for specific equipment limitations.

e. All flammable storage tanks must be grounded, and the ground system checked periodically.

3. Trailers - Trailer units of various capacities are used at most facilities. The following general rules apply to trucking equipment:

a. When loading or unloading, trailer wheels are to be locked, and wheel chocks must be in place.

b. The tractor shall not be engaged to or disengaged from a trailer while a transfer hose is connected to the trailer.

c. A warning flag on a stand is to be kept in front of the tractor or trailer as long as the transfer hose and

SAFE HANDLING OF CRYOGENIC LIQUIDS
AND ASSOCIATED EQUIPMENT

electrical ground are connected to the trailer. Before moving from the loading point, the equipment must be circled to ensure that all is clear and that the hose is disconnected. The flag can then be removed, and the trailer pulled from the spot.

d. The transport vehicle engine must be shut down before starting product transfer. The engine shall not be restarted until transfer is completed and hose is disconnected. Engine startup is prohibited until the area and the conditions surrounding the vehicle are considered safe (free of vapors, etc.)

IV. RELATED PROCEDURES

District Operations Manual - Volume 1, Section 9

V. RELATED FORMS

Air Products and Chemicals INC.

PUT IT IN WRITING

Date: June 12, 1968

TO: See Distribution

Subject: Test Gauge Equipment Failure

FROM: M. H. Hubbs

Shakopee

Distribution: Allegheny Operations Region Plant Managers
Eastern Operations Region Plant Managers
Midwest Operations Area Plant Managers

cc: W. L. Ball
J. H. Colby
W. L. Ent
W. T. Straughan
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June 9, 1968, Robert Wessinger, Plant Manager of Shakopee (near Minneapolis), was checking oxygen pressure on portable banks prior to shipment. One bank had been checked. The second bank was in the process of being checked when a fire occurred.

A test gauge with a rubber hose was being used for this purpose. An eight inch rupture and fire took place in the hose before the supervisor removed his hand from the valve; in other words, the fire was immediate.

Upon closing the valve, the fire went out.

Wessinger received second degree burns to his face and arms (in second degree burns, blisters develop). He was wearing safety glasses.

Findings

The investigation revealed the following:

1. Rubber hose was being used in oxygen service. A flexible metal hose should be used with the test gauge.

2. The test gauge and hose were being used in oxygen and nitrogen service.

   DOM Volume IV, 0130, Paragraph (4) 2 specifically prohibits the use of oxygen test gauges in service other than oxygen.

3. When not in use, the test equipment was left in a building, exposed to the atmosphere.

   When the equipment is not in use, it should be stored in a manner where foreign material cannot enter the hose.

APCI DOCUMENT NO. 19000284

4. Although definite identification has not been made, a material which looks like oil was found in the outlet orifice of the cylinder valve and the inlet side of the hose.

   The oil may have come from a nitrogen cylinder. Tests will be made on two oxygen cylinders removed from the portable bank for positive identification.

Your Required Action

1. Whether you fill cylinders in your plant or whether you don't, the idea of interchanges of gauges or pressure reducing regulators, etc., from any service to oxygen without the equipment being "cleaned for oxygen service" is prohibited.

   THIS POINT SHOULD BE STRESSED TO ALL OF YOUR EMPLOYEES.

2. You who have cylinder fill as part of your operation should check immediately those points made above to see that you are not violating the Company regulations. Place emphasis on the fact that pressure should always be introduced slowly to a gauge.

3. This information should be part of your next safety meeting.

4. You should be acquainted with the following references:

   a. F. K. Kitson's letter, Summary of Action Taken on Pressure Gauges, dated August 2, 1961.

   b. District Operations Manual, Volume IV, 0130.

ORIGINAL SIGNED BY

M. H. Hubbs

MHH:c

(Retyped 9/26/72 sba)

INDEX TO PARAGRAPHS

1. PURPOSE
2. SCOPE
3. GENERAL
4. CLEANING AGENTS
   4.1 DETERGENTS
   4.2 CHLORINATED SOLVENTS
   4.3 OTHER CLEANING AGENTS
5. ASSOCIATED EQUIPMENT AND SUPPLIES

1. PURPOSE This QCL lists the cleaning agents, associated equipment and supplies, which are approved for use in Air Products and Chemicals, Inc., manufacturing facilities.

2. SCOPE This QCL shall be used in conjunction with all Air Products and Chemicals, Inc. cleaning standards.

3. GENERAL

3.1 Due to the various problems involved in the handling of most cleaning agents, it is important that the users of these materials be thoroughly familiar with the specific problems of each cleaning agent.

3.1.1 The use of any cleaning agent is prohibited until all the problems concerning the agent are known, and the necessary precautions are established.

3.1.2 Any doubt, concerning the use of a cleaning agent, shall be resolved thru Quality Control or the Safety Department, prior to use of the agent.

3.2 Proper ventilation in a work area is mandatory. Inhalation of highly concentrated vapors will cause serious effects. Prolonged or repeated exposure of the skin to concentrated vapors or liquids may cause dermatitis.

4. CLEANING AGENTS

4.1 DETERGENTS

4.1.1 The capacity of holding tanks, in which solutions are contained, shall be determined before use.

4.1.2 Before adding detergent compounds, fill the container with water to approximately one-third of the intended working volume.

APCI DOCUMENT NO. 99002834

4.1.3 Add detergent compounds as follows:

4.1.3.1 POWDERS shall be sprinkled into water, at room temperature. DO NOT ADD POWDERS TO HEATED SOLUTIONS, OR IN BULK QUANTITIES.

4.1.3.2 LIQUIDS may be added to heated solutions.

4.1.4 After adding the compound, fill the container to the full working volume. Continue agitation throughout the filling period. Proper cleaning cannot be accomplished unless the mixing is thorough, and 100% complete.

4.1.5 Titration instructions are included in appropriate titration kits supplied for testing specific solutions.

4.1.5.1 The titration of a solution will be accomplished whenever its cleaning ability seems inefficient, or when the solution is weakened through the necessity of adding water.

4.1.5.2 Titration kits and replacement materials may be obtained from the manufacturer of the cleaning compound.

4.1.6 Detergent materials listed in this QCL will not effect teflon or nylon. Materials (other than the metals approved for each detergent) should not be processed in any solution without proper authority.

4.1.7 Detergent solutions are either alkaline or acid in nature and, therefore, are a potential hazard if disposed of carelessly. It is important that solutions are disposed of in the manner recommended.

4.1.8 MATERIALS PROCESSED THRU DETERGENTS MUST BE THOROUGHLY RINSED.

4.1.8.1 Material cleaned with an ALKALINE solution shall be immersed in a hot (180°F-200°F) water rinse for a period sufficient to allow the material to heat to the temperature of the water and for such additional time as is required to accomplish thorough removal of the cleaning agent. The rinse water shall be overflowing to prevent heavy contamination from carry over of the cleaning solution. If the configuration of an item results in a heavy carry over of cleaning solution to the rinse, it may be necessary to have more than one rinse. If this is the case, only the final rinse requires heating. The final rinse when tested shall indicate a pH of 6 to 8.

4.1.8.2 Material cleaned with an ACID solution may be rinsed in water, at room temperature. The rinse water shall be overflowing to prevent contamination from carry over of the cleaning solution. More than one rinse may be necessary and the final rinse may be heated to aid in drying. The

4.1.8.2 final rinse when tested shall indicate a pH of 6 to 8. (Contd)

4.1.8.3 Detergent solutions shall NOT be employed to clean a surface which, thru use, will contact oxygen rich atmospheres, unless the cleaned surface can definitely be determined as free of all cleaning solution after rinse.

4.1.9 The following detergents may be employed as applicable:

A. SOIL & OIL REMOVAL - Where identical compounds are specified for dissimilar metals, it is advisable to use separate solutions to clean ferrous and nonferrous metals.

Ferrous Metals (including stainless steel, invar, and nine-nickel):
#77 Oakite
JSTC Johar
#4 Johar (low foaming)

Aluminum & Aluminum Alloys:
#164 Oakite Aluminum cleaner (non-etching material)
#20 Johar

Copper & Copper Alloys (brass, bronze, monel and herculoy):
#77 Oakite
JSTC Johar
#4 Johar

B. RUST & SCALE REMOVAL

Ferrous Metals Only:
#32 Oakite (hydrochloric base)
Oakite Rustripper (also removes paint and varnishes).
#13 Johar

All Metals:

#31 Oakite (phosphoric base) (also removes oxides and fluxes).
#23 Johar

C. DEOXIDIZER & BRIGHTENER

Aluminum & Copper, and their alloys:
#34M Oakite (chromic base)
#22 Johar

D. RUST RETARDANT

All Metals:
Rinsite (also prevents water spotting).

E. CORROSION (water) STAIN REMOVAL

Aluminum & Aluminum Alloys:
#160 Oakite (Etching material) Rinses freely.
#21 Johar

4.1.10 The following detergents may be employed for the application listed:

A. HIGH PRESSURE SPRAY

All Metals:
#164 Oakite Aluminum Cleaner
#20 Johar

B. MANUAL CLEANING

All Metals:
#33 Oakite-(Phosphoric acid base). DO NOT use on white
#23 Johar metals. Removes oxides, rust, soils, and oils.
#202 Oakite-(Alkaline material). Removes soils and oils.
#25 Johar

4.1.11 Detergents shall be employed in accordance with the following instructions:

4.1.11.1 OAKITE #31 - Acid, liquid type (pH2)
(JOHAR #23)

Application: All metals. Has a minimal attack on aluminum materials. This attack increases as the concentration, temperature and time of contact increases.

Purpose: Removes oxides, rust, scale, light soils and fluxes. May also be used as an acid rinse (at concentrations of 1 to 2% by volume with water) after alkaline cleaning. HAS NO SOLVENT CONTENT. Specially suited for flux removal.

Mixing Proportions: 5% to 50% by volume, to water.

Operating Temperature: 160°F to 180°F.

Precautions: Add the acid to the water. Requires an acid resistant holding tank. Do not allow contact with the eyes or skin.

4.1.11.2 OAKITE #32 - Acid, liquid type (pH2)

Application: Ferrous metals only.

Purpose: Remove rust and scale. Strip oxide coatings, and remove chromium, zinc, and cadmium platings. Where cleaning is necessary, use a soil removing Oakite (Oakite #77) and rinse.

Mixing Proportions: Normal mix is 15% Oakite #32 with water, by volume. Concentrations of 5% to 50% by volume, may be used depending on the amount of rust and/or scale to be removed.

Operating Temperature: Up to but no exceeding 140°F.

Precautions: Add the acid to the water. Use in well ventilated area. Vapors of heated Oakite #32 solution are very corrosive. Requires an acid resistant holding tank. Do not allow contact with the eyes or skin. When the configuration of a component allows for entrapment of Oakite #32 solution, neutralization should be accomplished by introducing a solution of Oakite Rustripper (at a concentration of 2 oz. per gallon of water, at room temperature, employing a contact time of 5 minutes) and rinse.

4.1.11.3 OAKITE #33 - Acid, liquid type. (pH2)
(JOHAR #23)

Application: All metals. History of attack on aluminum same as listed in 4.1.11.1.

Purpose: Remove oxides, rust, scale, soils and oils. Has good detergent and solvent properties.

Mixing Proportions: 5% to 50% Oakite #33 to water, by volume.

Operating Temperature: Room temperature to 140°F.

Precautions: Add the acid to the water. Requires an acid resistant holding tank. Do not allow contact with the eyes or skin.

4.1.11.4 OAKITE #34M. Acid, powder type (pH2)
(JOHAR #22)

Application: Aluminum and copper, and their alloys.

Purpose: Deoxidizing, brightening and desmutting. A general bright dip. IMPORTANT: Oakite #34M is not a cleaning agent. Where cleaning is necessary, use a soil removing Oakite (Oakite Aluminum Cleaner #164) and rinse, prior to using Oakite #34M to deoxidize and brighten the material. Where etching of aluminum is necessary, use Oakite #160 (which rinses freely) and rinse, prior to using Oakite #34M to remove the residual black smut which generally forms when aluminum is etched. Heavy etching of aluminum also results from the use of Oakite #77 or Oakite Rustripper. These materials do not rinse as easily as Oakite #160. Because of the exceptionally heavy etching produced, the use of Oakite #77 or Rustripper to etch aluminum must be carefully controlled.

Mixing Proportions: 8 to 16 oz. per gallon of water.

Operating Temperature: Room temperature, DO NOT HEAT.

Precautions: Add the acid to the water. Reacts vigorously with ferrous metals. Requires an acid resistant holding tank. Do not allow contact with the eyes or skin.

4.1.11.5 OAKITE #77 - Strong Alkaline, powder type (pH14). (JOHAR JSTC & JOHAR #4)

Application: All metals except white metals. Not recommended for aluminum because a heavy etch is produced.

Purpose: Remove heavy deposits of soil and oil. Remove light deposits of rust and scale.

Mixing Proportions: 8 to 16 oz. per gallon of water.

Operating temperature: 160°F to 200°F.

Precautions: Do not use at temperatures below 140°F or when scum forms on the solution. Do not allow contact with the eyes or skin.

4.1.11.6 OAKITE #160. Alkaline, powder type (pH14) (JOHAR #21)

Application. Aluminum and its alloys.

Purpose: Etch aluminum. Remove corrosion (water) stains. Action is accelerated as the concentration, temperature and/or time of contact is increased.

Mixing Proportions: 3 to 6 oz. per gallon of water.

Operating Temperature: 140°F to 180°F. When aluminum is etched there is generally a residual black smut formed. This smut will usually not rinse off in a water rinse. To remove the smut and brighten the aluminum after etching and rinsing, process the material thru a solution of Oakite #34M, and rinse.

Precautions: Do not allow contact with the eyes or skin.

4.1.11.7 OAKITE #164. Alkaline, powder type (pH12). (JOHAR #20)

Application: Aluminum and its alloys. Specially inhibited to prevent attack on the material.

Purpose: Remove soil, oil and identification inks. Can be used in pressure spray equipment due to its low foaming properties.

Mixing Proportions: 2 to 8 oz. per gallon of water.

Operating Temperature: 160°F to 200°F

Precautions: Do not use at temperatures below 140°F. Do not allow contact with the skin or eyes.

4.1.11.8 OAKITE #202. Alkaline, liquid type (pH10) (JOHAR #25)

Application: All metals.

Purpose: Remove soils and oils. Suited for manual cleaning.

Mixing Proportions: May be used in a range of from 2% to water, by volume, to full strength.

Operating Temperature: Room temperature to 140°F.

Precautions: None.

4.1.11.9 OAKITE RINSITE. Neutral, liquid type (pH7-8).

Application: All metals. Use as an additive to rinse water.

Purpose: Prevent water spotting. Retard corrosion for a temporary period.

Mixing Proportions: 1/2 of 1% to 2% Oakite Rinsite to water by volume. (Use in final rinse only).

Operating Temperature: Up to but not exceeding 140°F.

Precautions: Freezes at 28°F. Store accordingly. Avoid contact with acids.

4.1.11.10 OAKITE RUSTRIPPER. Strong alkaline, powder type (pH14) (JOHAR #13)

Application: All metals except white metals. Not recommended for aluminum because a heavy etch is produced.

Purpose: Remove rust, scale, grease and oils. Strip paint and lacquers. Provide a temporary, light corrosion resistant alkaline film.

Mixing Proportions: For light rust (rust blush) removal, 8 oz. per gallon of water. For heavy rust removal, 3 lbs per gallon of water.

Operating Temperature: Room temperature for light cleaning and rust (rust blush) removal. 180°F to 200°F temperature for heavy duty cleaning and rust removal.

Precautions: Do not allow contact with the eyes or skin.

4.2 CHLORINATED SOLVENTS

4.2.1 All chlorinated hydrocarbon solvents will decompose when exposed to temperatures of 750° - 950°F. These products of decomposition are more toxic than the solvents; therefore, flame, heaters, and welding should not be permitted in the vicinity of cleaning with these solvents. The products of decomposition include phosgene gas.

4.2.2 Chlorinated hydrocarbon solvents will, in the presence of moisture, result in the formation of hydrochloric acid through hydrolysis. The hydrochloric acid, in addition to being reactive with aluminum, is more toxic than the original solvent. The elevated temperatures used in purging a vessel would increase the reaction of acid with aluminum and increase the hazard due to toxicity.

4.2.3 Equipment cleaned with chlorinated solvents by the flushing method shall be purged with a stream of clean, dry air or nitrogen. (It is advisable to exhaust fumes to the outside atmosphere.) The purge shall continue until the exhaust can be determined free of solvent vapors when tested with halogen gas detection equipment.

4.2.4 Chlorinated solvents shall be used in accordance with the following instructions.

4.2.4.1 TRICHLORETHYLENE. (Conforming to Federal Specification O-T-634A, Type II, and Military Specification Mil-T-7003.)

Application: All metals. May be used for cold cleaning or vapor degreasing.

Purpose: Remove oil, grease, fats, waxes, tar, rubber, sulfur, and resins.

Type or Grade: Neutral, stabilized, metal degreasing grade.

Operating Temperature: Use at ambient temperature will remove light soils, preserving oils and greases. Vapor cleaning, by use of any commercial degreasing equipment, is more effective and will remove heavy soils and oils. (Nonflammable solvent) Trichloroethylene boils at approximately 188°F.

Precautions: Use with good and adequate ventilation. The maximum allowable vapor concentration of trichloroethylene is 100 ppm. Vapors, when inhaled in sufficient concentration, will produce symptoms of anaesthesia, mild-giddiness, nausea, and in severe cases will cause unconsciousness.

4.2.4.2 METHYLENE CHLORIDE (Dow Chemical Company; DuPont Company; or similar)

Application: All metals. May be used for cold cleaning, vapor degreasing or hot stripping.

Purpose: Remove grease, oil solvent residue, lubricating compounds, and preservative oils and greases. In addition, its exceptional solvent activity permits quick stripping of paint and lacquer films, including latex and the new tough epoxy resin materials.

Type or Grade: Technical grade.

Operating Temperature: Use at ambient temperature will remove light soils, preserving oils and greases. Vapor degreasing or hot stripping are more effective. (Non-flammable solvent) Methylene chloride boils at approximately 104°F.

Precautions: Use with good and adequate ventilation. The maximum allowable vapor concentration is 500 ppm. (It would appear that under similar conditions the methylene chloride would be five times as safe as trichloroethylene. However,

the evaporation rate is about twice that of trichloroethylene, thereby producing a richer atmosphere of methylene chloride than would exist for trichloroethylene in the same period of time. When the evaporation rate is considered, it is evident that the ventilation requirements will be similar for both solvents.) Vapors, when inhaled in sufficient concentration will produce symptoms of anaesthesia, mild-giddiness, nausea, etc. - and in severe cases will cause unconsciousness.

4.3 Other cleaning agents.

4.3.1 ISOPROPYL ALCOHOL

Application: Rubber parts or surfaces only.

Purpose: Remove light soils, oil and grease.

Type or Grade: Commercial

Operating Temperature: Room temperature.

Precautions: Highly inflammable. Proper ventilation in a work area is mandatory. In the event of a spill, the alcohol must be cleaned up immediately. Compressed air or fans should not be used to dry up spills because of the highly flammable nature of the vapor. Mops and rags used to soak up spills should be dried outdoors.

4.3.2 PACO-ALCOHOL (Publicker Industries, Incorporated)

Application: All metals. Use when subsequent fabrication requires that a cleaned material be welded. May be used for spot cleaning.

Purpose: Remove oil, grease, enamels, inks, lacquers, varnish.

Type or Grade: TR590, Formula #2, Regular Type.

Operating Temperature: Room temperature.

Precautions: Highly inflammable. Use in well ventilated area. In the event of spill, the alcohol shall be cleaned up immediately. Compressed air or fans should not be used to dry up spills because of the highly flammable nature of the vapor. Mops and rags used to soak up spills should be dried outdoors. When used in confined areas for cleaning, an exhaust fan should be employed to expell concentrated vapors. Paco, Formula #2 has a flash point of 48°F. Paco shall not be used where the liquid or vapor could possibly be trapped in a system or an assembly. Use an Explosion Meter to determine the concentration of vapors in a work area whenever cleaning involves extended use of Paco and the vapors cannot be exhausted to the outside.

4.3.3 TART - ACID (The Dubois Company)

Application: Stainless steel and aluminum.

Purpose: Dissolves mineral deposits and prepares organic soil for easy removal by alkaline cleaners. Used as a light to medium duty pickle for removing rust. Also an effective brightener and deozidizer of aluminum.

Type or Grade: Commercial grade.

Operating Temperature: Room temperature.

Precautions: Use where acid cleaning is necessary. Immediately after the application of Tart, a thorough rinse with clean water is necessary. When subsequent welding will be performed, the weld joint surface should be wire brushed with a stainless steel brush after cleaning has been completed. Do not use where crevices could trap the Tart and prevent it from being rinsed out. Use proper precautions to avoid physical contact with the acid in order to prevent serious skin irritation.

5. ASSOCIATED EQUIPMENT AND SUPPLIES USED TO ESTABLISH & MAINTAIN CLEANLINESS

5.1 Black Light Inspection Equipment:

Pen-Ray Lamp, Model 11SC-1, Blacklight Eastern Corporation.

Blak-Ray Lamp, Model B-100, Blacklight Eastern Corporation; or Model ZB26, Magnaflux Corp.

Forescope, Lico Model 4258AP, Lenox Instrument Company.

5.2 Dacron or Nylon Clothing:

Commercial Type/Grade.

5.3 Polyethylene Materials:

Commercial Type/Grade.

5.4 Test Papers:

Filter - Commercial Type/Grade (e.g. Millipore, Whatman, etc.)

PH Indicator - Red Litmus for upper PH limit, Methyl Red for lower PH limit; or commercial, range type, hydrion papers.

5.5 Vapor Degreasing Equipment:

Commercial Type/Grade(such as Model V-S-500, Detrex Manufacturing Company.)

BYRON-JACKSON OXYGEN PUMP WASHOUT PROCEDURE FOR ANALYTICAL PURPOSES

I. PURPOSE

To establish a procedure for solvent washing BJ (Byron-Jackson) oxygen pumps for contamination analysis.

II. RESPONSIBILITY

Plant Managers, Maintenance Superintendents, and operating personnel are responsible for compliance with the provisions of this procedure as it applies to BJ pumps with which they are concerned.

III. PROCEDURE

A. Solvent Washing for Analysis

1. All tools used on the internal portions of the pumps are to be cleaned in solvent.

2. Although any APCI approved solvents may be used, trichlorethylene is preferred over methylene chloride. There will be less evaporation of solvent during the cleaning, and analysis results should be more accurate.

3. A clean container shall be used as a vessel in which to immerse the pump case and as a drain basin for the barrel and nozzle head. A solvent drum cut in half the long way and supported on blocks has been used and found practical. A small metal cup, for pouring solvent over parts, and both sample cans to be used shall be solvent cleaned and placed in the container (one sample can can be used in place of the cup). A clean, lint-free rag shall also be rinsed in clean solvent, and dropped in the container.

4. If a platform scale is available, the container, proper blocking, the rag, the cup, and the sample cans shall be placed on the scale. Remove one sample can, then weigh everything else. Record the weight and replace the sample can.

5. Pour the solvent into the container. A 10-gallon maximum is suggested, since the less solvent used, the more accurate the analysis results will be. Allow the solvent to stand for a few minutes, then stir

APCI DOCUMENT NO. 99000286

BYRON-JACKSON OXYGEN PUMP WASHOUT PROCEDURE FOR ANALYTICAL PURPOSES

and obtain a representative sample in one of the cans. Then check the weight, record it, and deduct the weight recorded in step A4 to determine the weight of the solvent to be used.

6. If a scale is not available, measure the solvent put in the container and obtain the sample after agitating. The amount of solvent to be used will be determined by the amount introduced less the sample quantity.

   Note: To minimize errors due to evaporation losses, do not weigh or measure solvent quantities until the pump is ready to be cleaned.

7. Pull the pump from the plant complete with the barrel, then remove the case from the barrel and disassemble the case. Make a visual inspection for oil under a bright white light, paying particular attention to bolts, bolt holes, barrel gasket surface, volutes, and the separating surface of the case. Perform all work adjacent to the solvent cleaning drum and place all parts on clean paper.

8. Immerse the pump case halves, barrel to nozzle head gasket, all case nuts and bolts, and the rotating assembly in the solvent (individually or together). Allow the above parts to soak for 15 minutes while agitating or pouring solvent over them as necessary. Pumps with sections too long for the container can be held at an angle with the bottom in the drum while solvent is poured over them and drained into the drum. Remove the pump parts and place on the clean paper. Drain all solvent possible into the drum before removing the parts.

9. Suspend the pump barrel over the solvent container. Use the cup or sample can to pour solvent on the inner sides of the barrel, permitting it to flow from the barrel drain into the container. Be sure that solvent does not wash down the external surface of the barrel.

10. Remove the packing from the nozzle head section and place a piece of clean heavy gasket material between the packing gland and the face of the stuffing box. Tighten sufficiently to hold solvent within the nozzle head. Suspend the nozzle head upside down at an angle of approximately 45 degrees over the container and pour solvent from the container into the nozzle head. The angle is necessary to displace the air in the expansion joint section for thorough cleaning. Rotate and agitate as necessary. Use the clean rag to wipe the flange section or other areas not covered by solvent. Drain the solvent into the container.

    Note: See B, below and the diagram for a further explanation for this cleaning.

BYRON-JACKSON OXYGEN PUMP WASHOUT PROCEDURE FOR ANALYTICAL PURPOSES

11. Blow out all sections of the nozzle head (pay particular attention to expansion joint area) with dry, oil-free nitrogen to evaporate all solvent and remove any packing material.

12. Weigh or measure the remaining solvent and obtain a representative sample.

13. Forward the samples to the Operations Department Safety and Service Manager with the following information:

    a. Type of solvent used.

    b. Quantity of solvent used.

    c. Quantity of solvent remaining after cleaning.

    d. Details on visual inspection.

    e. Hours pump had been in service.

    f. Date washed.

    g. Specify which pump (A or B). Sites with more than one plant must also include plant number.

B. Packing Area Cleaning

1. Several years ago, a potential hazard was uncovered when it was discovered that a considerable quantity of loose packing material and oil had lodged in the cavity immediately below the nozzle head diaphragm. Although some of the oil was believed to be from original manufacture, this cavity represents an accumulating area for contamination.

2. We have been advised by Byron Jackson that the distance between the upper extremity of the expansion joint and the bottom surface of the

BYRON-JACKSON OXYGEN PUMP WASHOUT PROCEDURE FOR ANALYTICAL PURPOSES

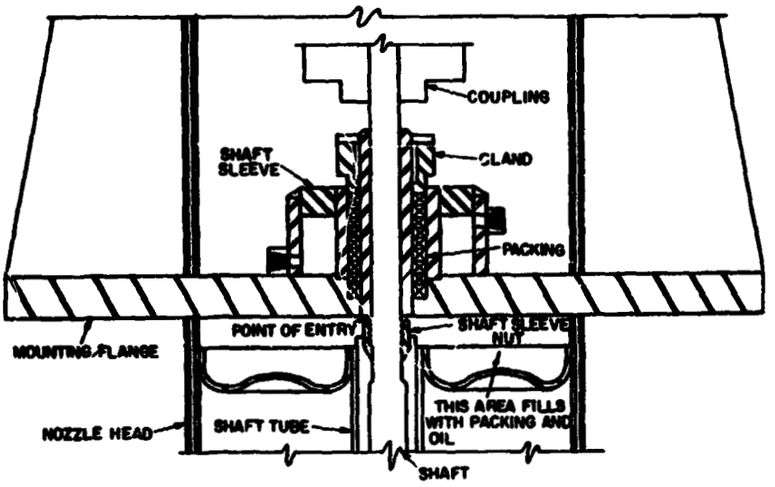
mounting flange is three-quarters of an inch in all pumps supplied to Air Products and Chemicals, Inc., with the exception of the following units:

Serial Numbers	370625-26	Weirton, West Virginia
	370641-42	Bethlehem Steel, Sparrows Point
	379476	Bethlehem Steel, Sparrows Point

On these pumps the dimension is 1-1/2 inches.

3. Extreme caution should be excercised by all in the inspection of these pumps after disassembly and cleaning.

4. Since a potential hazard exists, all personnel should be acquainted with the internal construction of these pumps. The diagram below illustrates the general construction of the area involved.



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BYRON-JACKSON OXYGEN PUMP WASHOUT PROCEDURE FOR ANALYTICAL PURPOSES

IV. RELATED PROCEDURES

1.05, Plant Solvent Washout - General

V. RELATED FORMS

VI. FREQUENCY

Refer to Section 5.08 of the Plant Operations Manual for frequency of pump washout for individual units.

Air Products and Chemicals INC

January 30, 1970

PRODUCT TEST PROCEDURES
1200 SERIES REGULATORS

I. WORK STATION LAYOUT:

WORK STATION 700
STATION NAME Test Manifold

A. Equipment Required:

1. Manifold header section
2. Header valve adaptors as required
3. 9/16", 5/8", 1-1/8" and 1-1/2" open end wrench, bonnet wrench (special)
4. Leak detector
5. Caplugs as required
6. Orificed test valves (see Table II for orifice size)

B. Test Manifold Setup:

1. Choose appropriate manifold header section and attach header valve adaptors if required.
2. Adjust manifold header section pressure as required in Table II.
3. Proceed with product test procedure.

II. PRODUCT TEST PROCEDURE:

1. Attach regulator to header valve, relieve adjusting spring pressure, attach orifice test valve to regulator outlet, open orifice test valve, open header valve.
2. Use leak detector to check for pressure leaks at the following places:

   (a) Inlet thread
   (b) H.P. gauge thread
   (c) Test valve orifice
   (d) Backcap

3. Turn the adjusting screw knob to full depth limit, observe the L.P. gauge for the following conditions:

   (a) Extreme interrupted motions of gauge needle during pressure buildup indicating "sticky" gauge.
   (b) "Minimum delivery pressure" must be obtained, as noted in Table II, by the time the adjusting screw knob has reached full depth limit.

4. Using the same series of motions as under 3 above, when adjusting screw knob has reached full depth limit, immediately relieve regulator pressure by turning the adjusting screw knob counter-clockwise until the L. P. gauge shows a reading below the test pressure setting specified in Table II, close orifice test valve, turn adjusting screw knob clockwise until correct test pressure is noted on L. P. gauge. Open and close orifice test valve twice, observe lockup and creep on L. P. gauge. Pressure increase shall not exceed values shown under "Lockup and Creep" column in Table II.

APCI DOCUMENT NO 99000287

NOTE: If regulator is found to be defective during test operations 1 thru 4, defects should be noted at point of rejection. Remove and replace regulator, repeat test operations 1 thru 4. If regulator is found to be satisfactory under above conditions, continue with the sequence of test operations 1 thru 4 above on additional regulators until all header test stations are in use, then proceed as outlined below.

5. Return to first header test station, recheck L.P. gauge for creep tolerance. If regulator does not exceed creep value, proceed with test operation 6 below.

   NOTE: If regulator is found to be defective at this point, note defect, remove and replace the regulator, proceed as noted under test operations 1 thru 4 above, move to header test station #2, proceed as noted under test operation 5 above.

6. Use leak detector to check for pressure leaks at the following places:

   (a) L. P. gauge thread
   (b) Outlet nipple pipe thread
   (c) Safety vents
   (d) Bonnet thread (large)

   If regulator passes leak test, proceed with test operation 7 below.

   NOTE: If regulator is found to be defective at this point, note defect, remove and replace the regulator, proceed as noted under test operations 1 thru 4 above, move to header test station #3, proceed as noted under test operation 5 above.

7. Close header valve, open test orifice valve to bleed pressure from regulator, remove test orifice valve, mark regulator boss at outlet nipple with inspection stamp, remove excess leak detector from regulator using shop air, clean regulator bonnet as required and attach regulator label, place caplug over outlet nipple, loosen inlet nut and remove regulator from header valve, place caplug over inlet nipple, place regulator aside onto regulator cart, note on daily quality control report.
8. Reload header test station just vacated and proceed with test operations 1 thru 4 noted above.
9. Proceed with test operations 5 thru 7 on subsequent regulators where test operations 1 thru 4 have been completed.

Air Products and Chemicals INC

III. FINISHED PRODUCT:

1. The finished product will be entered into the stock-room area when the shop order is complete. The product test inspector will date, initial and record the total number of units entered into stock on the reverse left hand side of the shop order card, the shop order card and all paperwork pertinent to the shop order shall be placed with the assemblies entered into stock area.

IV. GENERAL PROCEDURES:

1. Perform visual inspection during product test procedure.
2. Rejected regulator assemblies shall be identified with pressure sensitive labels, reason for rejection to be stated as briefly as possible, label to be applied to the back flat surface of regulator body.
3. Defective regulators shall be accumulated and scheduled for rework at the discretion of the immediate supervisor.
4. Since the immediate supervisor is responsible for maintaining a quality product, all questions pertaining to product test shall be directed toward him.

PRODUCT TEST PROCEDURES
1200 SERIES REGULATORS

TABLE II

COMMODITY NUMBER	MANIFOLD HEADER PRESSURE (PSIG)	TEST VALVE (ORIFICE) (#DRILL)	TEST PRESSURE SETTING (PSIG)	MAXIMUM LOCKUP AND CREEP (POUNDS-CFH-LITERS)	MINIMUM DELIVERY PRESSURE* (PSIG)
231-G-120054	1500-2400	#43	30	4#	50
231-H-120154	1500-2400	43	40	5#	100
231-A-120254	1500-2400	30	100	10#	175
231-4-121058	1500-2400	43	40	5#	100
231-0-122035	1500-2400	43	30	4#	50
231-X-122158	1500-2400	43	40	5#	100
231-L-123030	200-300	60	10	2#	15
231-Q-123151	200-300	60	10	2#	15
231-H-123251	200-300	60	20	2#	50
231-7-125055	1500-2400	43	40	5#	100
231-B-125158	1500-2400	43	40	5#	100
231-1-125255	1500-2400	43	40	5#	100
231-G-126035	1500-2400	43	30	4#	50
231-2-126155	1500-2400	43	30	4#	50
231-7-127032	800-900	73	30	4#	50
231-P-128058	1500-2400	43	40	5#	100
231-Q-128158	1500-2400	43	40	10#	175
231-9-128259	1500-2400	43	40	5#	100
231-7-128355	1500-2400	43	40	5#	100
**235-R-1123340	1500-2400	43	30	4#	50
**235- -1125450	1500-2400	43	40	5#	100
**235-0-2112110	200-300	60	10	2#	15
**235-E-2116450	1500-2400	43	40	5#	100
**235-U-2116470	1500-2400	30	100	10#	175

* With Test Valve Open

** Remove Inlet and Outlet Nipples and Plugs following Completion of Product Test, Place Appropriate Caplugs into Vacated Orifices.

(Retyped 9/26/72 sba)

OPERATING and SAFETY INSTRUCTIONS for REGULATORS and COMPRESSED GASES

Air Products and Chemicals INC.
WELDING PRODUCTS DIVISION

APCI DOCUMENT NO 990002188

SECTION I: INTRODUCTION

These instructions are provided with Air Products pressure regulators to assist the user in operating these regulators with safety and effectiveness. There are numerous hazards associated with the use of compressed gases. These hazards vary with each gas, with the equipment utilized, and with the particular application. It is, therefore, impossible to list all of the hazards and associated precautions. In addition to adhering to the operating instructions and safety rules listed in these instructions, the user should be aware of additional hazards and safe operating practices peculiar to his equipment and application and should consult with the equipment manufacturer and compressed gas supplier.

These instructions are applicable to pressure regulators used with oxygen, acetylene, nitrogen, helium, hydrogen, argon, liquefied petroleum gases (Propane, APACHI ™, MAPP*), natural gas and compressed air, when it is necessary to reduce a cylinder supply pressure source or a pipeline system source to a lower use pressure. Most regulators are similar in appearance, with the principal difference being at the inlet connection. Inlet connection standards are established by the Compressed Gas Association, the American Welding Society, and the American Standard Association. It is important that the inlet connection of the regulator is properly mated with the supply valve connection as specified by the established standards for the service intended. Checking proper mating will avoid putting the regulator into wrong service.

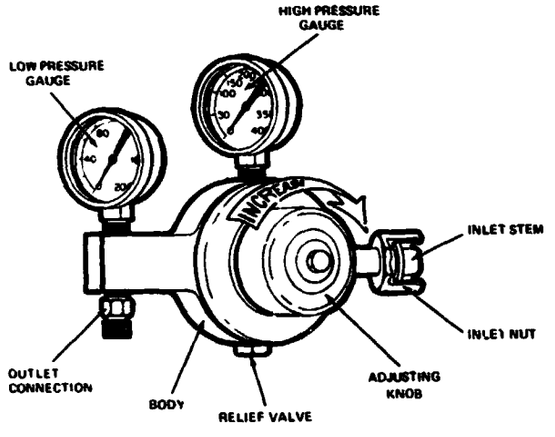
SECTION II: GENERAL OPERATING INSTRUCTIONS

A. PUTTING THE REGULATOR INTO SERVICE

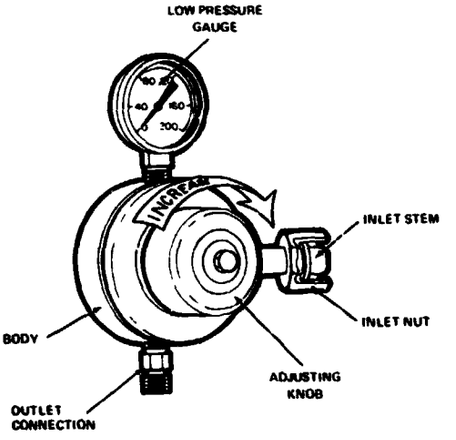
There are general safety rules for all gases and special safety rules for certain gases. These are listed in Sections III and IV. Refer to these sections before proceeding to operate the regulator.

*Registered trademark Dow Chemical Co.

1. Select a regulator which is proper for the gas and the service, making certain that a pipeline station regulator is never attached to a compressed gas cylinder.
2. Inspect the regulator for evidence of damage. If there is evidence of dirt, oil or grease at the inlet or outlet connections, use trichloroethylene or any good commercial chlorinated solvent to clean area(s) affected. Make certain that solvent does not enter the regulator while cleaning the soil affected areas. If solvent does enter regulator, send regulator to qualified repair station for cleaning. If excessive oil or grease are apparent, do not solvent clean, but send to qualified repair station for cleaning.
3. Inspect the supply connection for evidence of dirt, oil and grease. If evident, clean as in (2.). Open supply valve to blow out any loose foreign material. (Applicable only to oxygen, compressed air and inert gases; never blow out flammable gas supply valves.) Close the supply source valve.
4. There are general safety rules for all gases and special safety rules for certain gases. These are listed in Sections III and IV. Refer to these sections before proceeding to operate the regulator.
5. Attach regulator to source supply valve and tighten inlet nut.
6. Make certain the adjusting knob is backed out to its maximum counter-clockwise position. In this position, the regulator is closed and no flow will occur.
7. Slowly open the supply valve.
8. If purging of a system is desired, as is the case with inert welding systems, or is necessary in the case with oxygen/fuel welding, oxygen/fuel cutting and oxygen/fuel heating systems, follow the procedures prescribed for the particular equipment. A purging operation is a means of eliminating unwanted contaminants from a system. The regulator may be used to purge a system by turning the adjusting knob in a clockwise manner to establish a slight flow through the system to the atmosphere.



Typical Cylinder Regulator



Typical Pipeline Station Regulator

9. The regulator can now be adjusted to establish the required use pressure by referring to the proper gauge.

B. REMOVING THE REGULATOR FROM SERVICE

1. Close supply source valve.
2. Vent the gases in the regulator and/or the system to the atmosphere, or isolate the system and vent the gases in the regulator to the atmosphere by turning the adjusting screw clockwise to make certain no pressure is trapped in the regulator.
3. Disconnect the regulator from the supply source, if necessary.
4. If the regulator is to remain out of service, protect the inlet and outlet fittings from dirt, contamination or mechanical damage.

SECTION III: GENERAL SAFETY RULES

1. Never permit oil or grease to come in contact with Compressed gas cylinders, valves, regulators, hose, or fittings. Do not handle Compressed gas cylinders with oily hands or oily gloves.
2. Do not store oxygen and flammable gas cylinders together. They should be separately grouped and assigned a definite area for storage. The area should be dry, cool, well ventilated, and preferably fire resistant. Keep cylinders protected from excessive temperature rise by storing them away from radiators or other sources of heat. Cylinders should always be stored and used in an upright position.
3. Always refer to gases by their proper names - - "oxygen" and not by the word "air", "acetylene" and not by the word "gas" or "fuel".
4. Never use compressed gases from cylinders without a suitable regulator attached to the cylinder valve.
5. Never tamper with or attempt to repair cylinder valves.
6. Never use regulators, hose, or other pieces of apparatus with any other gases than those for which they were intended.
7. Never attempt to transfer gases to another cylinder or mix gases in a cylinder.
8. Never use compressed gases from pipeline systems without a suitable regulator at each withdrawal point.
9. Open cylinder valve fully when in use for all gases listed in this instruction except acetylene (see special rules for acetylene in Section IV).
10. Be certain that the cylinder valve is tightly closed and the cylinder cap is on before handling the cylinder.
11. When returning empty cylinders, make certain that the valves are tightly closed to prevent escape of residual gas.
12. Should a leak occur in a compressed gas cylinder, the cylinder should be moved outdoors away from other cylinders, combustible materials or equipment.
13. Removal of leaking cylinders to an outdoor location is necessary because:
    a. Combustible gases such as hydrogen, acetylene, propane, and other liquefied petroleum gases create fire and explosion hazards.
    b. Even inert gases such as nitrogen, argon, and helium create a hazard in that they can act as an asphyxiant by displacing the necessary amount of oxygen in in the air to sustain life.
    c. A leaking oxygen cylinder will increase the oxygen concentration in the air in the immediate area and create a possible fire hazard.
14. Provide adequate ventilation where compressed gas is being used.
15. Never drop cylinders or permit them to strike each other violently.
16. Avoid dragging or sliding cylinders, even for short distances. They should be moved by using a suitable hand truck.
17. Never tamper with safety devices in valves or cylinders.
18. Know and understand the properties, uses, and safety precautions of all gases before placing in service.
19. Do not use cylinders as rollers for moving material or other equipment.

SECTION IV: SPECIAL SAFETY RULES

When utilizing regulators for gases specified below, the following additional safety and operational rules must be followed:

OXYGEN

1. Never permit oil or grease to come in contact with oxygen cylinders, valves, regulators, hose or fittings, Do not handle oxygen cylinders with oily hands or oily gloves.
2. Never use oxygen near fires, open lights or flammable materials, especially grease, oil or any substance likely to cause or accelerate fire. Oxygen itself is non-flammable, but does support combustion.
3. Before attaching a regulator to an Oxygen cylinder, the inlet nipple and the porous filter in the nipple should be inspected for physical damage and contamination. If evidence of either is found, the parts should be cleaned or replaced.

   At regular intervals the filters in the inlet nipple and the high pressure chamber should be replaced with new parts.

ACETYLENE

1. Never use acetylene at pressures in excess of 15 psi. The use of higher pressures is prohibited by all insurance authorities and by law in many localities. To adjust for increased volume requirement, use large hose - - not increased pressure

2. When opening an acetylene cylinder valve, turn the key about one full turn.
3. Should a leak occur in an acetylene cylinder, take the cylinder out in the open air keeping it well away from fires or open lights.
4. Turn the acetylene valve so that the valve outlet will point away from the oxygen cylinder.
5. Keep sparks, flames, and heat away from acetylene cylinders.

HYDROGEN

1. The wide flammability range and the small amount of energy required to ignite air/hydrogen mixtures necessitates special handling of hydrogen to minimize possible damaging reactions. Care must be taken to eliminate sources of ignition such as sparks from electrical equipment, static electricity sparks, open flames or any hot object. An unconfined hydrogen/air mixture will burn rather than explode. Confined hydrogen/air mixtures, when ignited, explode with great force.
2. The hazards associated with hydrogen handling are fire, explosion and asphyxiation. Fire and explosion hazards can be controlled by employing proper operating procedures to prevent the formation of combustible fuel/oxidant mixtures and by removing or otherwise inerting potential sources of ignition (electric spark, static electricity, open flames, etc.) in the area where the hydrogen will be used. Adequate ventilation will help reduce the possible formation of flammable mixtures in the event of a hydrogen leak or spill and will also eliminate the the potential hazard of asphyxiation.
3. Know and understand the properties, uses, and safety precautions of hydrogen before placing in service.
4. Keep sparks, flames and heat away from hydrogen cylinders.

LIQUID PETROLEUM GASES

1. Liquid petroleum gases (LPG) include gases known as propane, APACHI and MAPP. Generally, they have similar characteristics in operation and are treated the same in safety procedures.
2. Particular attention must be directed towards ignition sources at ground level as the gas is heavier than air.
3. The hazards associated with the gases are fire and explosion, asphyxiation and cold temperature in a case involving spills of large quantities of this material.
4. The fire and explosion hazard may be minimized by understanding the properties of the gases, by establishing good work practices, by providing adequate ventilation in work areas, and by maintaining work areas free from combustible materials and sources of ignition. The vapors from the gases are heavier than air and will remain at a low elevation, therefore, placing a fire hazard at low level.
5. Smoking or open flames are prohibited in cylinder storage areas.

IMPORTANT

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set up and operating instructions for

Air Products

REDI-SET®

WELDING AND CUTTING OUTFITS

- AIRCRAFT
- MEDIUM DUTY
- MEDIUM DUTY ALL PURPOSE
- HEAVY DUTY

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APCI DOCUMENT NO 220002289

Air Products

Set Up and Operating Instructions

SAFETY RULES—OXYGEN

1. Never permit oil or grease to come in contact with oxygen cylinders, valves, regulators, hose or fittings. Do not handle oxygen cylinders with oily hands or oily gloves.
2. Never use oxygen near inflammable materials, especially grease, oil, or any substance likely to cause or accelerate fire. Oxygen itself is not inflammable, but does support combustion.
3. Oxygen cylinders should be chained to a wall, post, or in a cylinder cart in the upright position.
4. Always refer to oxygen by its full name—"oxygen", and not by the word "air".
5. Never use oxygen from cylinders without a suitable regulator attached to the cylinder valve.
6. Never tamper with, or attempt to repair, oxygen cylinder valves.
7. Never use oxygen regulators, hose or other pieces of apparatus with any other gases than those for which they were intended.
8. Never attempt to mix any other gases in an oxygen cylinder.
9. Open oxygen cylinder valve *fully* when in use.
10. Be certain that the cylinder valve is tightly closed before handling the cylinder and that the cylinder cap is screwed securely in place on the cylinder.

ACETYLENE

1. Never use acetylene at pressures in excess of 15 psi. The use of higher pressures is prohibited by all insurance authorities, and by law in many localities. To adjust for increased volume requirement, use larger hose,—not increased pressure.
2. Call acetylene by its full name, "acetylene", and not by the word "gas". Acetylene is far different than city gas or furnace gas.
3. Keep sparks, flames, and heat away from acetylene cylinders.
4. Should a leak occur in an acetylene cylinder, take the cylinder out in the open air, keeping it well away from fires or open lights. Notify the manufacturer at once.
5. Turn the acetylene valve so that the valve outlet will point away from the oxygen cylinder.
6. Acetylene cylinder key, for opening the cylinder valve, must be kept on the stem while the cylinder is in use so that the valve may be quickly shut off in an emergency.
7. When opening an acetylene cylinder valve, turn the key about *one* full turn.
8. When returning empty cylinders, make certain that the valves are tightly closed to prevent escape of residual acetylene, and that the cylinder cap is in place.
9. Never use acetylene regulators, hoses, or other pieces of apparatus with any other gases than those for which they were intended.
10. Never attempt to transfer acetylene from one cylinder to another, nor to refill an acetylene cylinder. Never attempt to mix any other gas, or gases, in an acetylene cylinder.
11. Never use acetylene from cylinders without reducing the pressure through a suitable regulator attached to the cylinder valve.
12. Acetylene cylinders should be used and stored in an upright position, chained to a wall, post, or cylinder cart.
13. Avoid exhaustion of acetylene from cylinder at a rate exceeding 1/7 of a cylinder's capacity, otherwise acetone will be drawn into the equipment. If greater volume is necessary, use manifold.

INSTRUCTIONS FOR SETTING UP CUTTING AND WELDING APPARATUS

A. Cylinder Handling (Handle only with protective cylinder valve caps in place):

1. Be sure that oxygen and acetylene cylinders are in an *upright* position and *chained* to a wall, post or in a cylinder cart.
2. Only after step one do you remove the cylinder caps which protect the cylinder valves.

B. Connecting Regulators:

1. Remove cylinder caps.
2. Before attaching regulators to the appropriate cylinders, blow out any dust which may be on the cylinder valve fitting by opening the cylinder valve for an instant and then closing the valve immediately. Make sure the cylinder valve outlet is facing *away* from you and any other person and *never* "crack" a cylinder valve near an open flame.
3. Attach oxygen regulator (Green Adjusting Knob) to oxygen cylinder and tighten using wrench No. 292-8-320156.
4. Attach acetylene regulator (Red Adjusting Knob) to acetylene cylinder and tighten using wrench No. 292-8-320156.
5. Make sure that adjusting knobs (Red and Green) on the regulators are released (turn knob counterclockwise until it turns freely).

C. Connecting Welding Hose to Regulators:

1. Green hose having *right* hand connection is used for oxygen service.
2. Red hose having *left* hand connection is used for fuel gas service.
3. Attach hoses to proper regulators and tighten nuts using No. 292-8-320156 wrench.

D. Opening Cylinder Valves:

1. Oxygen—With regulator in place and adjusting knob (Green) in full counter-clockwise position, stand to one side of regulator (never stand directly in back or in front) and *slowly* open cylinder valve *completely*. High pressure gauge (4000 lb.) will register cylinder content.

Set Up and Operating Instructions

2. Acetylene—With regulator in place and adjusting knob (Red) in full counterclockwise position, stand to one side of regulator as directed above and slowly open cylinder valve *one full turn only.*

E. Blow Out Hose By:

1. Oxygen—Turn green adjusting knob clockwise until 5 lb. pressure is recorded on low pressure or delivery pressure gauge and *immediately* release pressure by turning adjusting screw to complete counterclockwise position.
2. Acetylene or fuel gas—Follow same procedure as described above.

Important Note: Keep end of hoses away from open flames as you are blowing out the hoses.

F. Connecting Welding Torch:

1. With regulators and hoses attached as described above, attach the GREEN oxygen hose to the welding torch inlet stem marked "OXY." Attach the RED acetylene hose to the inlet stem marked "FUEL" and tighten with wrench No. 292-8-320156.
2. Insert the universal mixer assembly into the welding torch head and screw nut hand tight—no wrench required.
3. Screw desired size separable welding tip into the mixer. Select the proper size tip for the metal thickness to be welded *from the chart on Page 6*

G. Adjusting the Pressures for Oxy Acetylene Welding, Brazing, and Heating:

1. Partially open the torch oxygen valve and adjust the oxygen regulator until the pressure corresponds to that listed for the tip you have selected.
2. Close the torch oxygen valve.
3. Partially open the torch acetylene valve and adjust the regulator pressure, using the chart similar to the way you did it for the oxygen pressure.
4. Close the torch acetylene valve.
5. Note that the regulator pressure rises slightly when the torch valves are closed. That is the reason for setting the regulator at required pressure with the valve open. All pressures in welding and cutting charts are flowing pressures with torch valves open.
6. Test all connections to cylinder, regulators, and torch using soap water—if bubbles occur, retighten.

H. Apply Welding Goggles to Protect Eyes from Intense Cutting, Welding Brazing or Heating Light:

I. Lighting the Torch:

1. Hold the torch in one hand and the spark lighter in the other. (Always use a spark lighter).
2. Open the fuel gas valve approximately ¼ turn and *immediately* ignite using spark lighter.
3. Point the flame away from other people, the cylinders, or any flammable materials.
4. Adjust needle valve of torch controlling fuel gas until ignited fuel flame stops smoking and is ready to leave the end of the welding tip.
5. Open the torch oxygen valve until a bright inner cone appears on the flame. The point at which the feathery edges of the flame disappears and a sharp inner cone is visible is called the "Neutral Flame". Keep adjusting the torch oxygen valve back and forth until you are sure what a neutral flame looks like.
6. As the oxygen is brought in and before the two cones in the flame become one, a "carburizing" flame exists. When the two inner cones become one the flame is "neutral". Admission of more oxygen to the tip will produce an oxidizing flame with a sharply defined bluish to orange inner cone and an almost colorless outer cone. Use of a carburizing or oxidizing flame will produce boiling in the weld pool with resultant formation of porosity and or scale. A NEUTRAL flame should be used to obtain a clean, bright, smooth weld.

STEEL WELDING (Neutral Flame) OXY/ACETYLENE

Welding of steel is not difficult. Two factors are important: developing a good torch movement and selecting the proper heat by flame adjustment.

1. Follow operating instructions on CONNECTING WELDING TORCH.
2. *Position metal for welding.*
3. Turn on torch and adjust for a neutral flame.
4. Point torch flame directly at point where pieces of metal join together. Flame cone should be just above metal surface
5. When a puddle of metal forms, dip end of welding rod into puddle. Heat of molten puddle will melt rod. Slowly move torch back and forth in a direction toward rod. The melted rod will fill up the metal joint. (see Pages 4 and 5).
6. When weld is completed, let it cool. If weld is properly made, it will form a joint as strong as the metal itself.
7. For best results on 3/16 inch or thicker metal, grind a bevel of 30 on each edge. Be sure to fill gap in joint with weld metal to make weld.

BRAZE WELDING (Neutral Flame)

Braze welding is done by joining pieces of metal without actually melting the parent metal. The parent metals to be joined must be heated to a temperature slightly above the melting temperature of the brazing rod. Insert the rod into the joint allowing it to melt and flow into and around the joint, forming a strong bond. Clean, fresh flux must be applied as the operation proceeds to reduce oxidation and float oxides to the surface.

The big advantages of braze welding over steel welding are that different metals can be joined together, and repairs can be made on cast iron.

Before braze welding, the surfaces to be joined should be clean and properly fitted. Heat the joint until both pieces are a dull red color, and dip the rod into the can of all-purpose flux. (The flux will stick to the rod). When the flame is now applied to the rod and joint, the rod will melt and flow over the joint area and bond the pieces together.

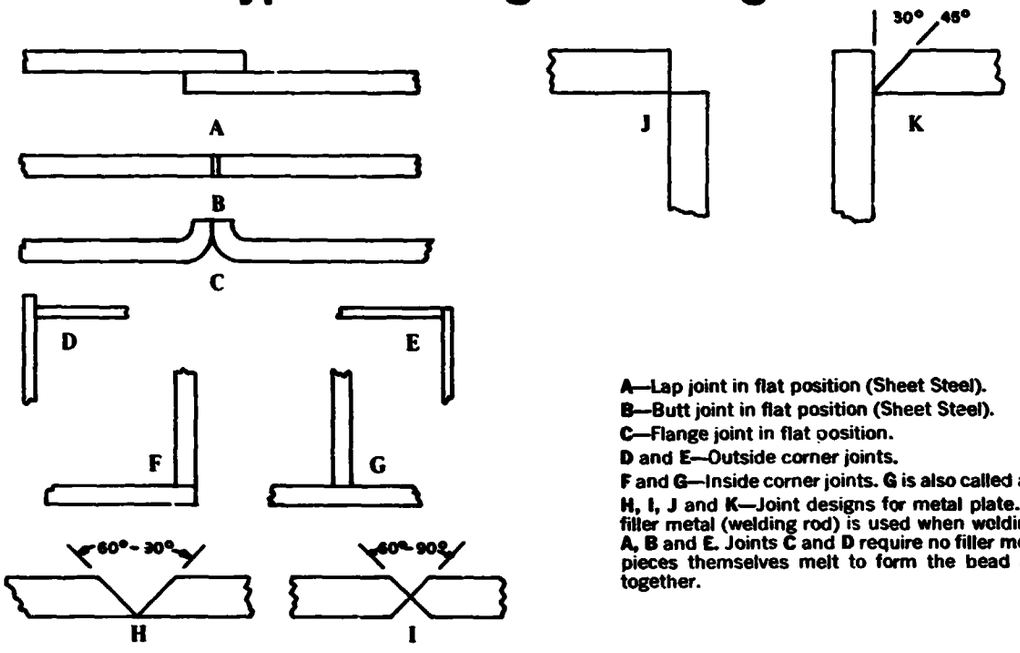
SILVER BRAZING

Silver brazing is faster than bronze brazing because silver has a lower melting point than bronze. However, silver will not bridge a gap as well as bronze, so it is important to have a tight joint of metal parts when silver brazing. Apply the flux directly to the joint of the metal parts, then heat with the torch. When heat has dehydrated the flux and flux becomes water clear, the brazing alloy is applied to the joint and by capillary action silver alloy will follow path and heat.

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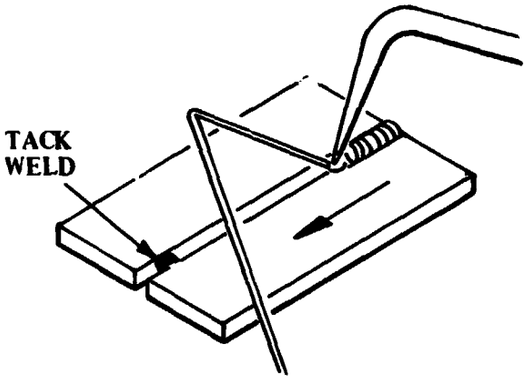
SET UP AND OPERATING INSTRUCTIONS

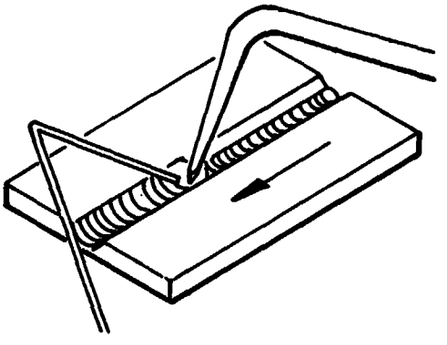
Typical Welding Joint Designs

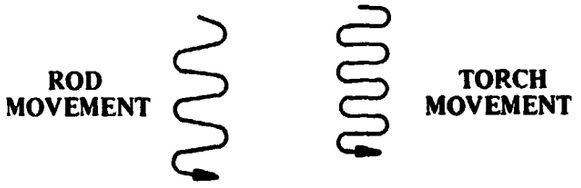


A—Lap joint in flat position (Sheet Steel).
B—Butt joint in flat position (Sheet Steel).
C—Flange joint in flat position.
D and **E**—Outside corner joints.
F and **G**—Inside corner joints. **G** is also called a T-joint.
H, I, J and **K**—Joint designs for metal plate. Note: A filler metal (welding rod) is used when welding joints **A, B** and **E**. Joints **C** and **D** require no filler metal. The pieces themselves melt to form the bead and join together.

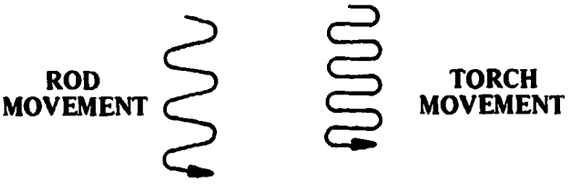
Recommended Welding Techniques







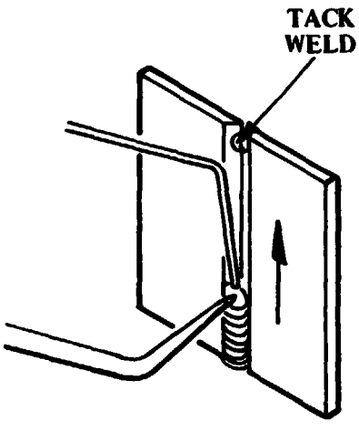
Spaced Butt Joint – Flat



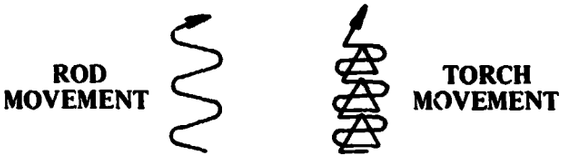
Flat Butt Weld – Multiple Pass

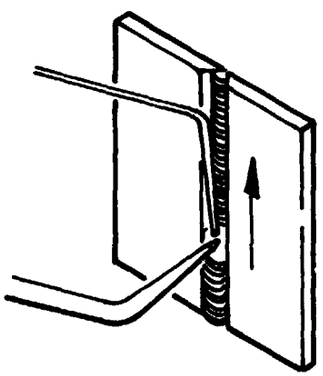
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Multiple Pass Beveled Butt Joint – Vertical Weld

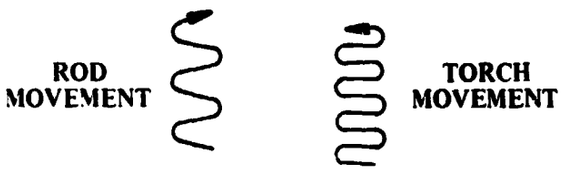


FIRST PASS

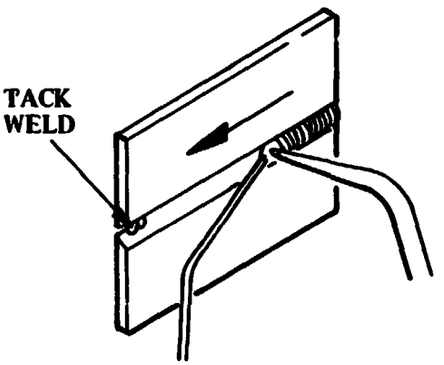




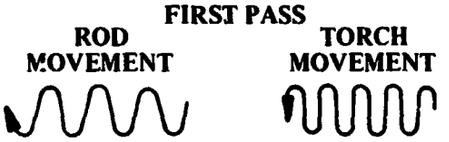
SECOND PASS

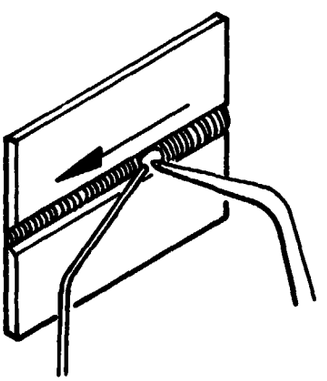


Butt Joint – Horizontal Weld – Multiple Pass

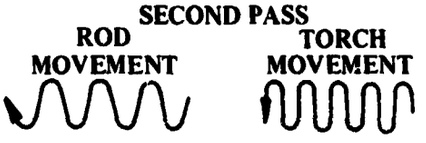


FIRST PASS





SECOND PASS



Air Products

Set Up and Operating Instructions

Tip Pressure Charts

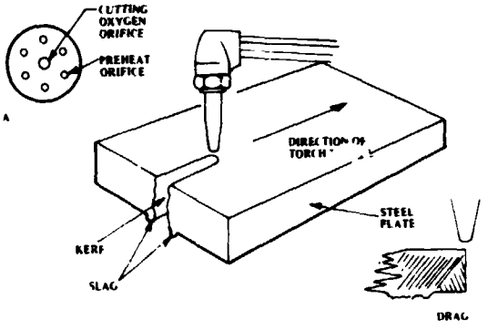
CUTTING TIPS			
Metal Thickness Inches	Tip Size	Oxygen Pressure PSI	Full Acetylene Pressure PSI
⅛"	00	30	3
¼"	0	30	3
⅜"	1	30	3
½"	1	40	3
¾"	1	45	3
1"	2	50	3
1¼"	2	60	4
1½"	3	45	4
2"	3	50	4
2½"	4	50	4
3"		45	4
4"	5	60	4

WELDING TIPS			
Metal Thickness Inches	Tip Size	Oxygen Pressure PSI	Full Acetylene Pressure PSI
1/64"	00	1½	1
1/32"	0	1½	1
1/16"	1	2	1½
3/32"	2	2½	2
⅛"	3	3½	3
5/16"	4	5	4
¼"	5	6	5
5/16"	6	7	6
⅜"	7	8	7
½"	8	8	7

PSI—pounds pressure per square inch

USING THE CUTTING ATTACHMENT

1. Follow set up instructions for Connecting Welding Torch (see Page 3—Item F).
2. Make sure needle valves on oxygen and acetylene are closed.
3. Connect cutting attachment to welding torch handle and tighten connecting nut hand tight—(use no wrench).
4. Select the tip size suitable for the job from the cutting tip selection chart.
5. Be sure that the taper cone seat on the cutting tip is free from dirt and nicks and insert into the cutting attachment head.
6. Tighten tip nut using No. 292-8-320156 Wrench—Do not use excessive force.
7. Adjust regulators to recommended pressures as per cutting tip selector chart.
8. *First*—Open oxygen valve on the welding torch handle *completely*. This oxygen valve supplies the preheat oxygen adjusted by the valve on the cutting attachment as well as the cutting oxygen lever.
9. Open preheat oxygen valve on cutting attachment and depress cutting oxygen lever. Adjust oxygen regulator to pressure recommended in chart below while oxygen is flowing through the cutting attachment. Release cutting oxygen lever and close preheat oxygen valve tightly.
10. Open acetylene valve on welding torch handle and adjust acetylene regulator to recommended pressure while gas is flowing. Close acetylene valve on welding torch.
11. To light the preheat flame, open the acetylene valve on torch handle about ½ turn and immediately ignite with *spark lighter*.



12. Open the acetylene valve until the flame clears the end of the tip about ⅛ of an inch, then reduce slightly to return the flame to tip.
13. Slowly open the preheat oxygen valve until a neutral flame is established—sharp inner cones.
14. After the neutral flame has been established as described, depress the cutting oxygen lever. Note that the preheat flames change slightly from neutral to a carborizing flame with a feather.
15. With the cutting oxygen lever in the depressed position, readjust the preheat oxygen valve until the preheat flames are again neutral.

Air Products

USING THE CUTTING TORCH— OXYGEN ACETYLENE OR OXYGEN PROPANE

1. Reference the proper cylinder handling, safety precautions and installation of regulators—See Page 2—Items A thru E.
2. Attach the Green oxygen hose to the cutting torch inlet stem marked "OXY". Attach the Red fuel gas hose to the cutting torch inlet stem marked "FUEL GAS". (Left hand thread).
3. Tighten nuts with wrench No. 292-8-320156.
4. Make sure both needle valves *are closed.*
5. Select the tip size suitable for the job from the cutting tip selector chart.
6. Be sure that the taper cone seat on the cutting tip is free from dirt and nicks and insert in the cutting attachment head.
7. Tighten tip nut using No. 292-8-320156 Wrench—Do not use excessive force.
8. Adjust regulator to recommended pressure as per cutting tip selector chart.
9. Open oxygen valve on cutting torch and depress cutting oxygen lever. Adjust regulator to pressure recommended in cutting tip chart while oxygen is flowing through the torch. Close valve securely.
10. Open fuel gas valve on cutting torch and adjust fuel gas regulator to recommended pressure while gas is flowing. Close needle valve securely.

Important Note: Make sure that no open flame is present when the above adjustments are made.

HOW TO START CUTTING USING A CUTTING ATTACHMENT OR CUTTING TORCH

1. Item of steel to be cut should be placed where flammable materials cannot be ignited by the molten metal and sparks from the welding or cutting operation. Be sure hoses are clear of molten metal and sparks.
2. Take your time and direct the preheat flame over the steel to be cut holding the *end* of the preheat flame just above the steel to be cut.
3. When a cherry red spot appears and the steel begins to melt, depress the cutting oxygen slowly.
4. When the cut has started, move the torch in the direction you wish to cut. A good cut is indicated by its sound of sputtering (similar to tearing sandpaper) and a steady stream of sparks and molten metal.

TURNING OFF THE CUTTING ATTACHMENT OR CUTTING TORCH

Shut off and close the acetylene needle valve *first.* Then close the oxygen valve on the cutting torch.

TOTAL SHUT DOWN OF WELDING EQUIPMENT, CUTTING ATTACHMENT AND CUTTING TORCHES

1. Shut off *both* cylinder valves *first.*
2. Open fuel gas needle valve on torch and ignite and burn off residual fuel gases.
3. Shut off fuel gas needle valve securely.
4. Open oxygen needle valve on torch and release residual oxygen.
5. Shut off oxygen needle valve securely.
6. Turn both oxygen (Green) and fuel gas (Red) regulator adjusting screws completely counterclockwise.
7. Flashbacks may result from mixed gases in either oxygen or acetylene hose. By following these rules acetylene will not get over into the oxygen line nor oxygen over into the acetylene line when starting up or shutting down. If the torch flame is properly adjusted and maintained, with the correct pressures, and the tip outlets kept free from obstruction, flashbacks will be eliminated.
8. The regulators must be removed before moving the cylinders. Replace the cap over the cylinder valve before cylinders are unchained from wall, post or cylinder cart.

REPAIR PROCEDURES

When repair of equipment becomes necessary, contact the local Air Products district office or authorized Air Products distributor—Consult the yellow pages for the office nearest you.

WARRANTY

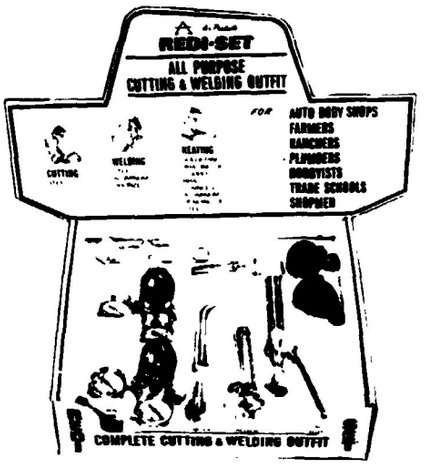
The Company warrants that the goods to be supplied hereunder will conform to the description on the invoice; that it will convey good title thereto, that such goods will be delivered free from any lawful security interest or other lien or encumbrance unknown to Buyer, and that such goods will be of merchantable quality. As to goods manufactured by Company, Company warrant: that such goods shall be free from defects in materials or workmanship for a period of one year from the date of delivery thereof, except that Company makes no warranties of merchantability or otherwise with respect to design if the goods are made in compliance with Buyer's design or specifications.

There is no warranty that the goods shall be fit for any particular purpose, nor is there any warranty, express or implied, except such as is expressly set forth herein. The Company shall not be liable for any incidental or consequential damages for any breach of warranty, the Company's liability and the Buyer's exclusive remedy being expressly limited at the Company's option to the repair of defective goods or the replacement thereof with conforming goods at the delivery point shown on the invoice or the repayment of the purchase price.

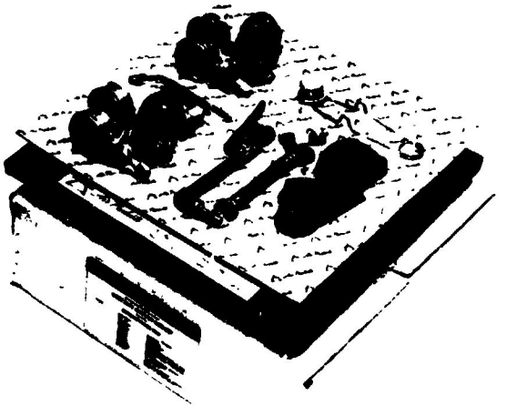
Replacement of defective goods or repayment of the purchase price therefor will be made only upon return of the defective goods which may be returned at the cost of the Company only after inspection by the Company and receipt by Buyer of definite shipping instructions from the Company.

As to goods not manufactured by Company, the sole obligation of Company shall be to obtain for Buyer from the manufacturers thereof the standard warranty available from such manufacturers and to lend the Buyer reasonable assistance with respect to the enforcement thereof.

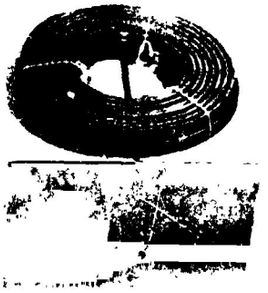
COMBINATION WELDING AND CUTTING REDI-SET® OUTFITS



MEDIUM DUTY



AIRCRAFT





HEAVY DUTY

(a) Inlet Conn. CGA 300
(b) Inlet Conn. CGA 510
(c) Inlet Conn. CGA 520

OUTFIT	COMM. NO.	WELDING TORCH	WELDING TIPS	CUTTING ATTACH.	CUTTING TIPS		OXYGEN REGULATOR	ACETYLENE REGULATOR	ACCESSORIES HOSE	ACCESSORIES OTHER
MEDIUM DUTY Inrd'd Type Cutting Tips	211-N-2103	224-7-2820	Style 150 Sizes 1,3,5	223-4-6229	Style 121 Size 1	224-L-380068 Mixer	231-N-110154	231-T-113130 (a)	3/16" 12½' 291-K-3021	Goggles 933-H-6506
	211-J-2108							231-T-113130 (a)	3/16" 25' 291-C-3022	
	211-A-2204							231-F-113351 (b)	3/16" 12½' 291-K-3021	Lighter 292-D-1111
	211-D-2206							231-F-113351 (b)	3/16" 25' 291-C-3022	
MEDIUM DUTY Conical Type Cutting Tips	211-X-2102	224-7-2820	Style 150 Sizes 1,3,5	233-Y-6229	Style 159SL Size 1	224-L-380068 Mixer	231-N-110154	231-T-113130 (a)	3/16" 12½' 291-K-3021	Goggles 933-H-6505
	211-R-2107							231-T-113130 (a)	3/16" 25' 291-C-3022	
	211-H-2203							231-F-113351 (b)	3/16" 12½' 291-K-3021	Lighter 292-D-1111
	211-L-2207							231-F-113351 (b)	3/16" 25' 291-C-3022	
MEDIUM DUTY All Purpose Conical Tips	211-F-2104	224-7-2820	Style 120 Tip/Mixer Sizes 1,3,5	223-Y-6229	Style 159SL Size 1	Style 225 Htg. Tip Assy.	231-N-110154	231-T-113130 (a)	3/16" 25' 291-C-3022	Goggles 933-H-6505
	211-4-2206							231-F-113351 (b)		Lighter 292-D-111*
HEAVY DUTY Conical Tips	211-1-3100	224-3-3820	Style 130 Tip/Mixer Sizes 1,3,5	223-R-6329	Style 159 Size 2	- - -	231-7-140054	231-A-143030 (a)	1/4" 50' 291-F-4123	Goggles 933-H-6505 Lighter 292-D-1111
	211-T-3200							231-E-143151 (b)		Wrench 292-8-320156
AIRCRAFT Conical Tips	211-R-1401	224-7-1921	Style 140 Sizes 0,2	223-5-6129	Style 1414 Size 1	224-7-400068 Mixer	231-N-110154	231-Y-113452 (c)	3/16" 12½' 291-D-3031 "A" Conn. one end, "B" Conn. other end	Goggles 933-H-6505
	211-5-1201							231-F-113351 (b)		Lighter 292-D-1111

Air Products and Chemicals INC

PUT IT IN WRITING

DATE: October 25, 1971

TO: A. Lapin

FROM: J. J. Kokinda

SUBJECT: 1200 Series Regulator - Material of Construction #231-G-120054 (Oxygen) Drawing #000-0-407004E Rev. F, June 7, 1971

cc: W. R. Collins, Jr.

(Doc. #99000290)

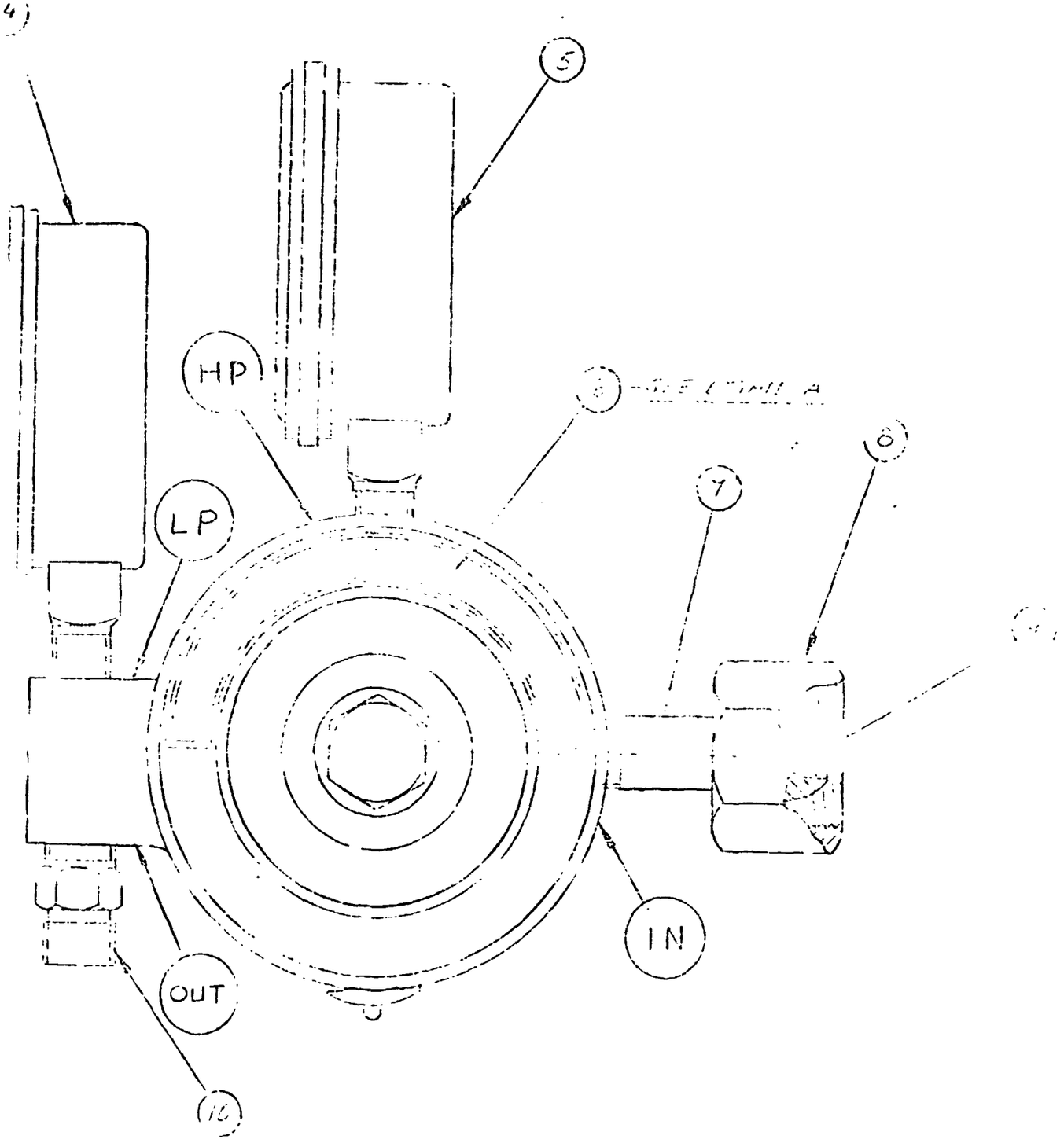
Materials of construction of the various parts of APCI Oxygen regulators are tabulated below. Part numbers are identified on the attached sketches #1 and 2.

Part No.	Part Name	Material
1	Body	Aluminum Alloy 6061-T6
2	Bonnet	Aluminum Alloy 6061-T6
3	Diaphragm Assembly	Molded Assembly
3a	Diaphragm	Stanglo #MN60-708 - Chloroprene (ASTM D735-58T SC712 BE,E_3, F_2)
3b	Washer	Brass - ASTM B36-49T - Alloy 6 or 8 - 1/2 HD.
3c	Plate	Brass Forging - ASTM B124-49 Alloy #2
4	Gauge, 60 psi 2-1/2"	Brass
5	Gauge, 4000 psi 2-1/2"	Brass
6	Naneplate, green	Laminated aluminum foil - (Alt. - Plioform)
7	Inlet nipple	Brass
8	Inlet nut	Brass - ASTM B16-49
9	Inlet Filter	Sintered Bronze - Grade fine (1000)
10	Outlet Bushing	Brass, 1/2 HD - ASTM B16-52
11	Cap nut	Aluminum - 2011-T3
12	Adj. knob - green	Phenolic
13	Bearing	St. Stl. tp. 302
14	Ball Bearing	Nice ball bearing #5673 (Cat. 125A)
15	Adj. Screw assembly	
15a	adj. screw	St. Stl. tp. 416
15b	spring button	Copper-silicon alloy - ASTM B98-52 Alloy #A7-hard temper
15c	stop pin	ESNA 790028-125-0500 or eq.
16	Adj. spring	Stl. ASTM A229-41, Cad. Pl.

APCI DOCUMENT NO. 99000290

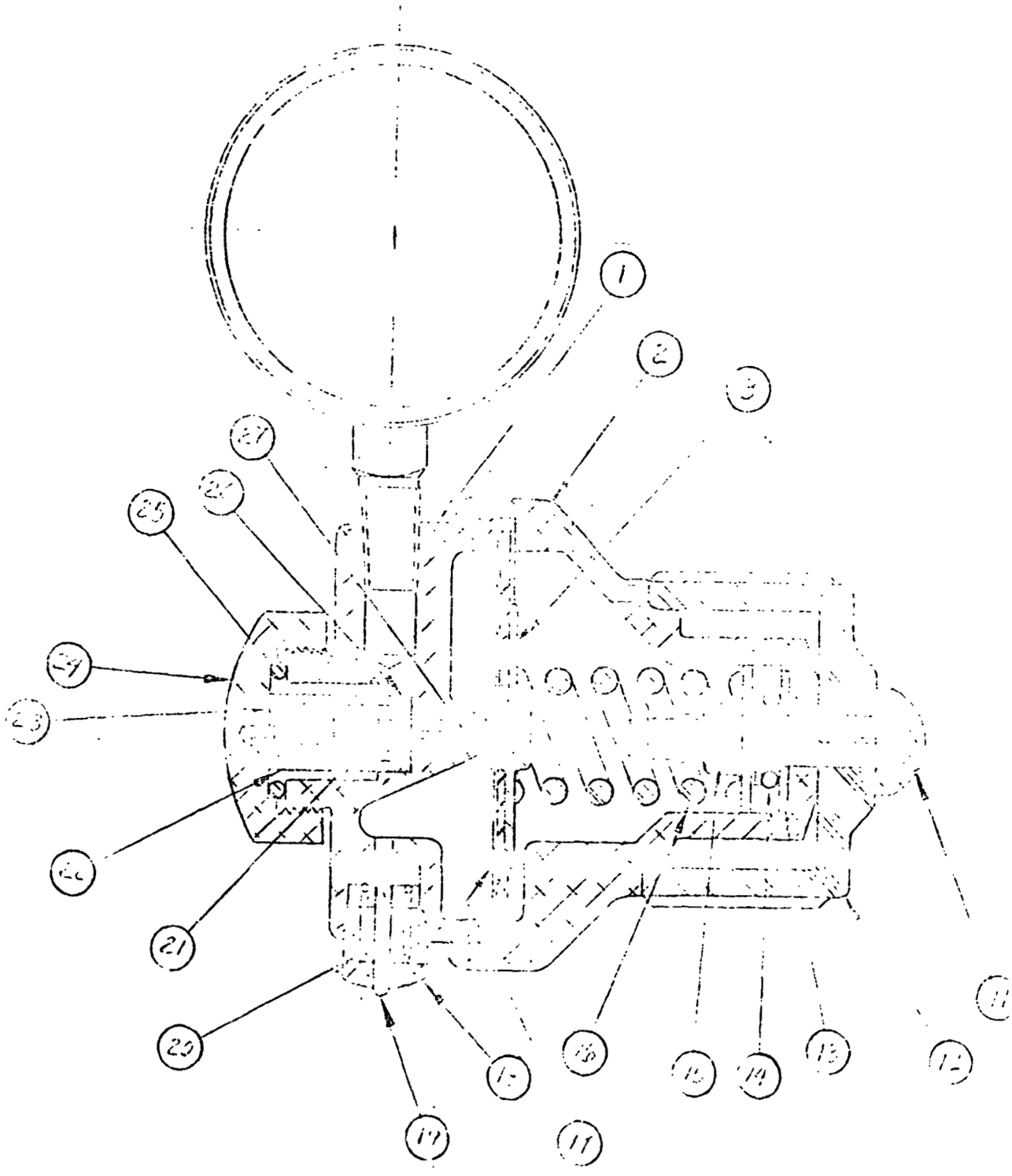
Part No.	Part Name	Material
17	See #3	
18	Safety Cap	Aluminum-Alcoa 2011-T3 or Eq.
19	Molded Safety Valve	
19a	Seal	Star-Glo #MN60-708 Chloroprene ASTM D735-58T SC712 BE, E_3, F_2
19b	Stem	Brass - ASTM B16-49 - 1/2 HD.
20	Safety Spring	St. Stl. Tp. 302
21	Valve Stem	St. Stl. tp. 416 ASTM A276-55 (alt. st. stl. tp. 303 ASTM A276-55)
22	Filter	St. Stl. tp. 318 or eq. - Chrysler Corp., Amplex Stl. gr. 20
23	Plunger Spring	St. stl. tp 302
24	Back cap	Aluminum - 2011-T3
25	O-ring	Cloroprene, Durometer 70, SC 712 BE, E_3, F_2
26	Seat	Nylon
27	Valve Pin	St. Stl. 18-8, tp. 303 ASTM-57T - cold worked high tensile - polished - min. yield strength 100,000 psi - min., tensile strength 125,000 psi.

REPRODUCIBILITY OF THE ORIGINAL COPY IS POOR,



SKETCH #1

REPRODUCIBILITY OF THE ORIGINAL COPY IS POOR.



SKETCH #2

Air Products and Chemicals INC.

INTER-OFFICE
MEMORANDUM

Date July 26, 1971

Subject Testing of Screens to be used in Oxygen Compressor Suction

To B. W. Taylor
(Location, Organization, or Department)

From A. Lapin
(Location, Organization, or Department)

cc: C. McKinley
J. C. Tafuri
K. Wilson (APL)

This memo is issued, as per your request, to summarize test work performed on October 16, 1970, to evaluate the performance of screens to be used in conjunction with stainless steel, perforated plates with 3/8" holes in the oxygen compressor suction. The design calls for the following:

a.	1/8" hole in support plates	400 psi burst pressure
b.	1/4" hole in support plates	250 psi burst pressure
c.	3/8" hole in support plates	70 psi burst pressure

The tests were performed by E. Sherer in the presence of the following: B. Taylor, J. Tafuri and A. Lapin. The equipment used is sketched in Figure 1.

The first test was run with a plastic sheet alone, and the plastic burst pressure was 18 psi, with the 3/8" hole.

Then, several tests were run with three different screens 3/4" diameter, with a loose plastic sheet as a sealant. No failures of the screens were obtained up to 400 psi with pressure maintained for 3-5 minutes. The pressure was then released.

A small 1/16" hole was punctured in the screen, and testing repeated. The system was again sealed with loose plastic sheets. No failure occurred at 200 psi, and the screen hole did not increase in size. Several layers of plastic were required to keep the set-up reasonably tight.

A 3/16" cut was made in the screen, and the test repeated. The system was made tight with plastic, and no failures occurred up to 400 psi. However, the cut opened up in size. At 200 psi the screen cut remained intact.

Two cuts at right angles, 3/16" each, were made in the screen, and again the system pressurized, with a loose plastic sheet as a sealant. No failures occurred at 200 psi; however, the opening grew in size, but there was no tearing of the screen.

In conclusion, the monel screen that you supplied for testing, 100 mesh, 0.0045" diameter wire, was tested successfully over a 3/8" hole, and was found to maintain its integrity at pressures up to 200 psi, even with small punctures or cuts.

ORIGINAL SIGNED BY

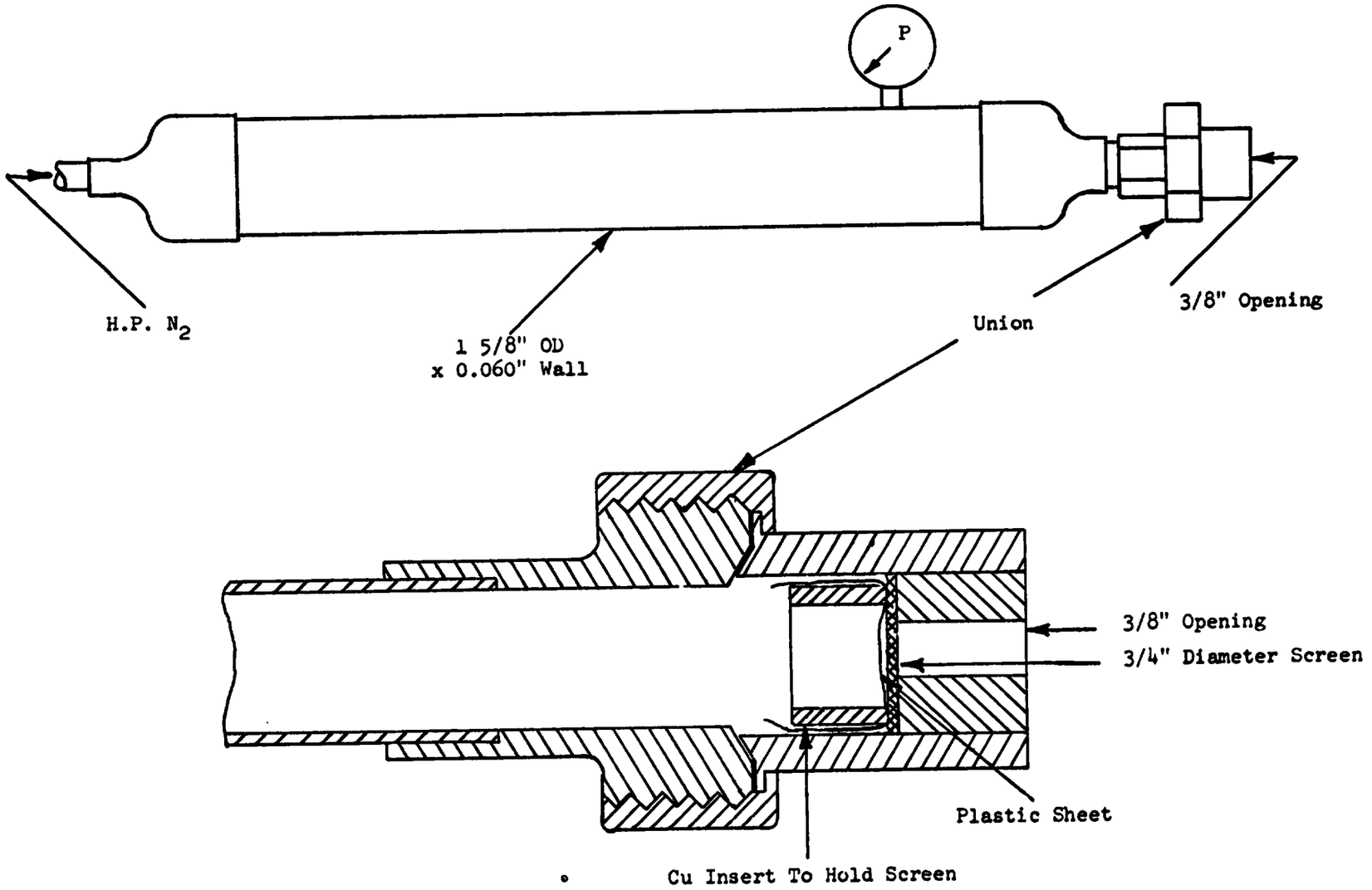
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(Retyped 9/26/72 db)

339

APCI DOCUMENT NO 9900291

Figure 1


P
H.P. N_2
1 5/8" OD
x 0.060" Wall
Union
3/8" Opening
3/8" Opening
3/4" Diameter Screen
Plastic Sheet
Cu Insert To Hold Screen

Air Products and Chemicals, Inc.

November 1, 1968

W. L. Ball

F. K. Kitson

Insulation Materials for

Cryogenic Systems

cc: C. E. Hepler
S. S. Paterno

This memo is in reply to your note regarding the flammability tests on insulation materials reported in the memo from G. Schmauch to A. Karalis dated October 24, 1968. This will also serve to record the general safety philosophy which has been agreed upon by S. Paterno and the writer.

As you will recall, a considerable number of tests have been run on insulating materials; principally, urethanes in air and in oxygen enriched atmospheres ranging up to 35%. These tests were conducted in an enclosure which was provided with a glass panel to permit observation of the results of the tests. The atmosphere in the enclosure was established and then the tip of a propane torch flame was impinged on the urethane sample. The tests that had been run in the past indicated Milfoam urethane insulation as being the most fire resistive urethane insulating material available on the market at that time. One of the areas discussed in the cost reduction program was finding an alternate to Milfoam which would keep the Milfoam Corporation competitive when quoting to APCI.

Within the past six months, a urethane was tested which appeared to offer, for all practical purposes, a comparable degree of fire resistivity to the Milfoam. This material, National Gypsum Blue, is being used in the design specifications as an alternate to Milfoam.

In addition to the burning tests, a test was performed to determine the reaction of several urethanes saturated in LOX when a source of impact was added. These tests indicated the reaction resulted in a very rapid rate of combustion but did not result in an explosive-type of reaction.

Based on an evaluation of the above test, it has been the writer's recommendation to Design Engineering that the following guidelines be used in specifying insulation for cryogenic systems.

APCI DOCUMENT NO 92000292

1. LOX Systems

Foam-Glas should be continued as the only material suitable for installation on LOX piping. One deviation was granted at Cleveland where the close proximity of the piping did not permit the use of Foam-Glas. In this instance, Milfoam was approved with the additional precaution of providing Foam-Glas insulation for a distance of 5 feet on either side of any possible points of leakage such as flanges and valves.

In reply to a question raised by S. Paterno, I have indicated that on any long isolated runs of LOX piping I believe it would be practical to use the same approach as used at Cleveland and use Milfoam with barriers of Foam-Glas at points of leakage. This area will be discussed further with Design Engineering when the need arises.

2. Liquid Hydrogen Piping Systems

The writer had approved the use of Milfoam several years ago on liquid hydrogen piping and therefore also approved the use of National Gypsum Blue. Your note indicated the use of National Gypsum Green at the New Orleans liquid hydrogen facility. As I recall the circumstances, an order was placed with Milfoam for all liquid hydrogen piping insulation. However, due to the limited manufacturing of the facility of Milfoam Corporation, it was necessary to approve an alternate urethane to meet the project schedule. At that time, the tests had indicated that National Gypsum Green was preferable to the other urethanes that were available.

3. LNG Systems

The original design specifications for urethane insulation on the Esso exchangers and piping (at higher elevations) required the use of Milfoam. As the Milfoam Corporation could not supply the quantities of insulation required with this project and tests had just been completed which established National Gypsum Blue as being an approximate equal to Milfoam in fire resistivity, it was recommended to the customer that National Gypsum Blue be specified as an alternate to Milfoam. Tests were then conducted by Esso research, the results of which concurred with our tests and satisfied the customer as to the fire resistivity and structural integrity of the National Gypsum Blue insulation after being subjected to a severe flame test.

4. Inert Cryogenes Below the Dew Point of Air

The insulating materials approved for these systems are Milfoam and National Gypsum Blue.

5. Inert Cryogenes Above the Dew Point of Air

As the problem of cryo-pumping and oxygen enrichment in an insulating system which is broken does not exist, we have approved the use of any urethane which is self-extinguishing in an air atmosphere such as UNARCO.

I have heard numerous reports that our competitors utilize urethanes on LOX piping. I suspect that their selection of urethanes is not based on tests such as APCI has conducted and there have been no reports of serious problems due to this practice.

The above information was dictated without the benefit of reviewing the voluminous material that has been accumulated on this subject. I believe the information is essentially accurate. Discussion with S. Paterno and C. Hepler indicated that the Design Section would, when time was available, review all the tests that had been run and compile a summary of the tests and the evaluation of the tests. As there is a substantial savings in the use of utethane insulation over Foam-Glas and the exposure appears to be very minimal, it is my opinion that the policies stated above are realistic and should be continued.

ORIGINAL SIGNED BY

F. K. Kitson

FKK:bp

(Retyped September 26, 1972, cju)

Air Products and Chemicals, Inc.

PUT IT IN WRITING

Date October 24, 1968

TO: A. J. Karalis

SUBJECT: Flammability Tests on Insulation Materials WO LA-0333

FROM: G. E. Schmauch

cc: W. L. Ball
N. C. Hallett
D. R. Latshaw
A. Lapin
C. McKinley

As you requested, flammability tests were performed on four samples of insulation material. The tests were performed by observing the burning characteristics of the material when exposed to a flame in air and when exposed to a flame in air immediately after soaking in enriched liquid air (40% oxygen) for a few minutes. The materials tested are listed below with the results of the tests.

Material	Flammability in Air	Flammability in Air After Exposure to Enriched Liquid Air
Vascocel	Burned in flame, self-extinguished immediately upon removal from flame	Burned more intensely in flame until liquid air in pores had evaporated then acted as in air alone.
Milfoam	Same as above	Same as above
National Gypsum (green)	Burned in flame, self-extinguished upon removal from flame with some after glow.	Same as above
Foam-Glas (Corning)	Did not burn - appeared to melt at point where flame struck the surface. Heated areas became extremely brittle	Responded as in air.

ARCH DOCUMENT NO 9900223

In addition, a sample of Vacocel and a sample of Milfoam were tested in the following manner. A 3/16" diameter hole was drilled about 2" deep into a 1" x 1" x 3" sample of Milfcam and into a 1/2" x 1" x 3" sample of Vascocel. These samples were immersed in the 40% oxygen enriched air and the hole filled with liquid. The samples were then exposed to the flame at the hole opening. In both cases, extensive burning persisted even after removal from the flame until the enriched liquid air had been consumed or evaporated.

ORIGINAL SIGNED BY

George E. Schmauch

GES:mes

(Retyped 9/26/72 db)

Air Products and Chemicals INC

LINDE AIR FRACTIONATION PLANT EXPLOSION

by

A. Lang

Safety in Air and Ammonia Plants

Volume 4, PP71-80

1962

APCI DOCUMENT
NO 99 000 234

Air Products and Chemicals INC

SAFETY IN AIR AND AMMONIA PLANTS

by

P. W. Reynolds
Imperial Chemical Industries

Safety in Air and Ammonia Plants

Volume 2, PP31-36, 1960

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Air Products and Chemicals INC.

OXYGEN PLANT REBOILER EXPLOSION

by

R. W. Rotzler

Safety in Air and Ammonia Plants

Volume 2, PP31-36, 1960

APCI DOCUMENT NO. 19000296

Air Products and Chemicals INC

OXYGEN PLANT VAPORIZER EXPLOSION

by

G. T. Wright

Dominion Foundry and Steet, Ltd.

Safety in Air and Ammonia Plants

Volume 3. PP9-12, 1961

APCI DOCUMENT NO. 99000397

Air Products and Chemicals INC

OXYGEN PLANT EXPLOSION

by

L. G. Mathews

Safety in Air and Ammonia Plants

Volume 3, PP12-16, 1961

APCI DOCUMENT NO. 99000298

Air Products and Chemicals INC

OXYGEN TRAILER FIRE

by

G. G. Pinney

Safety in Air and Ammonia Plants

Volume 4, PP49-50, 1962

National Cylinder Gas Co.

APCI DOCUMENT NO 99000299

Air Products and Chemicals INC

DISCUSSION OF ENERGY RELEASE IN A LIQUID OXYGEN PUMP

by

W. Leonard Ball

Air Products and Chemicals, Inc.

Safety in Air and Ammonia Plants

Volume 5, PP41-42, 1963

APCI DOCUMENT NO 9000120

Air Products and Chemicals INC

LIQUID OXYGEN PUMP FAILURES

by

J. J. Rendos

Safety in Air and Ammonia Plants

Volume 9, P5, 1967

APCI DOCUMENT NO. 9999-30

A I R P R O D U C T S L I M I T E D

OPERATIONS DEPARTMENT

Title: Report on Service Visit to H.M.S. EAGLE

Air Products Limited reference: X 0425

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Issued by: A. A. Moore

Date: 18 August 1971

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APCI DOCUMENT NO 99000302

H.M.S. Eagle - X 0425

Object of Visit

During normal operation of the port LOX plant on H.M.S. Eagle a fire started in the H.P. oxygen storage system which caused considerable damage to the plant equipment and severe damage to the equipment in the near vicinity. The object of the service visit was to advise what work should be carried out to put the plant in working order, and to make any suggestions with regard to the safety of the plant.

Brief Description of Incident

The opening of a storage valve is known to be the initiating event causing the fire. The pipework burnt back to the necks of the three bottles in service. In doing so the fire penetrated the deck above the storage bottles and also burnt and severed the dump line from the LOX storage tank. It is probable that the majority of the contents of the LOX storage tank was dumped into the compartment through this ruptured line and caused the fire to spread.

Description of Photographs

Reference numbers are on the negatives; numbers allocated by the photographic section of H.M.S. Eagle.

G.6132 LOX storage vessel. The top cover of the vessel is covered with debris from the melted ducting above it. The burnt dump line can just be seen on the photo, most of the severed end being concealed by the storage fill line. (Storage fill line runs from top right of picture to centre nozzle). The material hanging from the top of the compartment shown on the top left of the picture is the wreckage of ventilation ducting and a burnt out cable.

G.6130 Showing the hole burnt through the deck above the storage vessels and the remnants of the fittings in the necks of the bottles. The flanged valve and pipe propped between the vessels is the remains of the liquid dump line.

G.6131 LOX pump. The drier outlet valves can be seen to the left of the spot light. The asbestos wrapped flange and line at the bottom right of the photo is the liquid dump line transition in the cabin deck.

A.P.L. ref. X 0425 Photo 1. Hole burnt through deck taken from dental surgery. Diameter of floodlight is approximately 12 inches.

G.6147 Comparison of burnt valve with new valve taken from stores.

G.6145 End view of burnt valve in G.6147.

G.6148 and G.6149 Side and end views of a burnt out valve.

G.6152 View of burnt out valve with remnants of pipe fused to it.

G.6143 View of valve spindle with part of the valve fused to it.

G.6124 A.S.U. Instrument panel all instruments burnt beyond repair, including the valve position indicators on the valves below.

G.6153 Showing damage to aluminum floor of compartment near to the foot of the HP O_2 storage vessel. Concrete below the aluminum was eroded to the depth of approximately 1/2" to 1".

G.6137 LOX pump. Similar view to G.6131.

G.6154 Shows burnt pipework and the wricked internals of the cambridge purity recorder.

G.6127 Shows the one vessel which did not burn back to the cylinder neck. (Valve was shut and vessel was empty).

A.P.L. Ref. X C425 Photo 2. Similar to G.6127.

G.6157 HP O_2 pipework union Tee.

Work to be carried out on Plant.

1) Remove all A.S U. panels and perlite also slag wool from driers. Water from the fire hoses will have penetrated the insulation, new perlite and slag wool to be installed.

2) Inspect pipework for damage.

3) Repair/Overhaul LOX pump. As the compartment was filled level to the door sill (about 2 ft.) with water the pump/motor unit was virtually immersed. Pump to have plunger removed, valves removed and checked, suction and discharge filters checked. Mechanical parts of pump to be overhauled and pump reassembled using new packing.

4) Repair damaged vacuum pipework on LOX storage tank and pull vacuum on the vessel during inspection of the LOX storage vessel. Soon after the fire an audible leak was heard from the damaged vacuum isolation valve, it was some hours before the vacuum was completely lost, for this reason, and the lack of obvious damage, that it is assumed that the storage vessel has no internal damage.

5) Make good connection on vacuum insulated part of LOX pump line. Suggested method shown in sketch X 0452SK.1. It will probably be necessary to support the dump valve in order that the weight of the valve and the dump line is not thrown on to the vacuum insulated line.

6) Remove dessicant from driers, replace with new. Change dessicant in CO_2 filters. Change dessicant in hydrocarbon adsorber on pump jacket inlet.

7) Fit new instrumentation, checking that instrument isolation valves and exterior pipework are in good condition replacing where necessary.

8) Remove all relief valves and check that set pressures are to design, refit.

9) Pressure test plant using clean dry nitrogen, and soaping all joints. If it is found on some circuits that it is not possible to reach all joints a drop test may be carried out, i.e. filling a section to test pressure and then timing loss of pressure. With the small capacities involved, there should be no noticeable drop over half an hour. It is suggested that the plant be tested to normal working pressure as in this way the relief valves can be left insitu and will protect all circuits. The integrity of the relief valves will also be proved. It is possible that a slight weep from a relief valve will give a noticeable drop in a circuit in which case this may be acceptable. (What is acceptable and what is not can only be decided on site for each case). The pressure test should be the final job when only repacking and defrosting remain to be done.

10) Repack box. (Maintain pressure in plant so damage to pipework will show up as a pressure loss).

11) Defrost plant. Using the normal defrost procedure the plant should be given a thorough defrost making sure that every line, including gauge lines, blowdowns and the storage are done.

A I R P R O D U C T S L I M I T E D

SERVICE DEPARTMENT

7 August 1971

APPENDIX A

H.M.S. Eagle X 0425

Spares required for port plant

Item	Quantity	Description	R.N. Ref
1)	2	Manometer 6"	
2)	2	P.G. 0-5000 psig 6"	024/942/0634
3)	2	2 1/2" Thermometers - 100°C/ +60°C	753/755107
4)	4	Level Indicator 0-50" W.G. AE Model 227	107/955000
5)	2	P.G. 0-5000 psig 6"	821/137002
6)	3	P.G. 0-200 psig 6"	821/137001
7)	1	P.G. 0-30 psig 6"	821/137
8)	2	2 1/2" Thermometers 200°F/ 600°F 4" stem	107/287095
9)	2	2 1/2" Thermometer 20°F/ 220°F 4" stem	107/287094
10)	14	Valve handwheel indicators type 801	
11)	1	Freon expansion valve complete	107/980836
12)	1	Oxygen valve complete	107/980828
13)	16	N.35 Oxygen valves complete	
14)	200 ft.	Cupro-nickel piping	0282/13531
15)	20	Sleeve comm. bronze	0251/13535
16)	20	1/4 X 1/4 X 1/4 Tees. bronze 600 psi. Fitting No. 03 Drwg. No. E.M. 4049. Unions and nipples for piping item 14	

APPENDIX A (Cont'd)

Item	Quantity	Description	R.N. Ref
18)	4	Tee pieces - storage bottle comm. Al. bronze 6000 Drwg. No. 3810. Fitting No. A.G.X. 16-19 Fitting list Dev. MED 62799	
19)	2	Needle valves	657-287239
20)	1	Needle valve	657/287238
21)	1	Tank level gauge	107/011583
22)	1	Vacuum gauge and isolating valve assembly	119/287151
23)	1	Cambridge purity recorder, complete with flow indicator	
24)	1	Air drier heater unit and switch	
25)	1	Defrost heater unit and switch	

A I R L I M I T E D L I M I T E D

SERVICE DEPARTMENT

7 August 1971

APPENDIX B

Contracts

BATH	Lt. Cdr. John Highton	X 3984	
	Cdr. Sharrock	X 3975	
EAGLE	Cdr. Peter Howard		
	Lt. Cdr. Ashley Teape		
	S/Lt. Allen Rapkins		
	C.ERA Alford		
	C.ERA Old		
	ERA Lay		
GARDEN ISLAND	Lt. Cdr. Roberts	35044	(H.M.A.S. KUTTABUL)
		X 278	(office)
		X 409	(ward room)

SUPPLIERS

Foam glass)
Rockwool)
Perlite)

Bradford Insulation Industries Pty.
7 Percy Street
Auburn, Sydney 649 9741

MR. FORD

Mr. Ron Quinn - Promotional Manager, Sydney
Mr. Hankie - Depot Manager, Perth

Perth Address

13 Corkill Street North
Fremantle

(Rockwool: 7 days notice required for supplier at Perth)

Perlite 2/3 days Sydney, longer in Perth, supplied in 4 cu. ft. bags.

BECKMAN, analyser agents

H. B. Selby
Sydney 888 7155

Mr. Graham Vale

(D.2 delivery quoted as 6 weeks minimum.)

SAFETY/IE/PR 13 September 1971

NOTES ON VISIT TO H.M.S. ARK ROYAL ON 11/8/71 TO DISCUSS SAFETY OF SHIPBOARD LOX PLANTS

1. Meeting attended by:

D.G.S. (Bath)	R.N.	A.P.L.	Hale-Hamilton
D. Pearce	Cdr. James	D. Ellis	B. Hall
	Lt-Cdr Kersey	I. Everson	
	Lt-Cdr Rose		
	Lt-Cdr Wright		

2. R.N. explained that the causes of the Eagle incident are in doubt due to the extent of the damage. Possible causes are:

2.1 Use of an unsuitable valve seat e.g. nylon.

2.2 Use of unsuitable '0' ring materials e.g. neoprene or nitrile rubber.

2.3 Presence of compressor lubricating oil in valve which had somehow passed through the entire plant.

2.4 Sudden opening of the storage vessel Hale-Hamilton valve permitting excessive velocities and high temperatures due to oxygen recompression which ignited the valve seat '0' rings.

2.5 The Tee pieces above the oxygen vessel concerned may have developed a crack.

3. Thereafter the meeting concerned itself only with the Ark Royal Plants.

4. Mr. Hall stated that Hale-Hamilton valves used on these air separation plants for compressed air (N9) and oxygen (N35) are externally indistinguishable. It was proposed to affix identification discs under handwheel retaining nuts. An unspecified Atcheson lubricant has been used for air separation plant valves.

5. Components for oxygen service e.g. valves, are degreased by vendors and sent to Naval Stores in sealed polythene bags. The control once these bags are opened appeared to be less satisfactory. Operators are not required to wear clean cotton gloves for example.

6. The situation concerning '0' rings was regarded as somewhat unsatisfactory. Present D.G.S. policy is to use only HOSTAFLON '0' rings. However it was not clear how many of the previous rubber '0' rings are still in use in Hale-Hamilton valves. It was incorrectly assumed that as these '0' rings were trapped they would not be exposed to high temperature, high pressure oxygen resulting from valve maloperation.

7. The large H.P. oxygen vessels are occasionally blown down through a 1/4" bore pipe. Occasionally these have become completely blocked. If these rust particles find their way into regions exposed to high temperatures, high pressure oxygen they could ignite, perhaps acting as kindling for a more serious fire.

8. Valves on top of the oxygen vessels are inaccessible, thus an operator attempting to adjust such a valve could easily open it suddenly accidentally. Better access was agreed as very desirable.

9. The 4 stage reciprocating air compressor delivers air at 3600 psig. No special significance is attached to air temperatures. APL stressed the importance of this parameter to avoid air compressor explosions. APL also stressed the importance of periodically cleaning out intercoolers, aftercoolers, and surge drums.

10. Full records of cylinder lubrication rates have not been kept. The importance of this was recognised.

11. Oil adsorber units have been inspected. Traces of oil were found only near the inlet of the first unit. It was concluded that no lubricating oil should have penetrated into the A.S.U.

12. The importance of maintaining the correct LOX level in the reboiler-condenser was not appreciated by the E.R.A. in charge of the plant.

13. The vacuum pump connected to the LOX storage vessel vacuum jacket was provided with 2 solenoid valves for breaking vacuum in the event of a power failure to prevent oil being sucked into the vacuum jacket again. No oil catchpot was installed.

14. No consideration has been given to solvent washing the plant in case lubricating oil has been deposited around the plant. It appears that the columns cannot be solvent washed.

15. APL stated that Beckman portable oxygen analysers are no longer regarded favourably in view of their lack of robustness and that SERVOMEX instruments are now preferred. However, the Beckman instrument is satisfactory provided it is handled carefully. APL undertook to send details to Mr. Pearce.

16. APL stated that the practice of sampling the contents of the LOX tank when the plant was shutdown did not serve any useful purpose so long as appreciable evaporation did not take place. Persumably the anticipated hazard concerned concentration of contaminants should significant evaporation occur.

17. The cold box atmosphere is never sampled so that leaks cannot be detected until frost spots appear.

18. H.P. oxygen at about 3000psi is piped to the aircraft hangar through rigid pipes. Flexible pipes are then used for cylinder filling. These pipes had rubber external covers. APL pointed out the hazard if they had rubber internal linings.

19. D.G.S. does not recommend use of Klingerit as a gasket material as they believe that Klingerit contains appreciable quantities of organic matter. APL pointed out that they use Klingerit extensively and that organic free material is available.

20. In view of the points raised by APL, Mr. Pearce said he would contact APL new Malden to seek assistance in reviewing the Naval Air Separation Plant Operational Procedures.

D. Ellis (Plant Manager, Stocksbridge)
I. Everson (Chief Safety Engineer)

Distribution: M. H. Vogel, A. Dick, J. Friend, D. Ellis, A. A. Moore, I. Everson

MINUTES OF MEETING HELD ON BOARD HMS ARK ROYAL ON WEDNESDAY, 11 AUGUST 1971 TO DISCUSS LIQUID OXYGEN SAFETY REQUIREMENTS

1. Present:

Mr. R. B. Pearce	D. G. Ships
Cdr. P. James	FOCAS
Lt. Cdr. I. Rose	DGA(N)
Lt. Cdr. J. E. Kersey	FDEO HMS ARK ROYAL
Lt. R. Wright	FDLO " " "
Mr. C. Wollerton	CDL Devonport
Mr. J. E. Hall	Hale-Hamilton (Valves) Ltd.
Mr. I. Everson	Air Products, Ltd.
Mr. D. A. Ellis	" " "

2. DG Ships stated that the meeting had been called to investigate aspects of safety related to the ARK ROYAL LOX plant arising from the recent explosion in HMS EAGLE. The Board of Inquiry into the explosion had made recommendations which required urgent consideration to establish if there were shortcomings in ARK ROYAL which would require work being done during the current maintenance period at Devonport. FOCAS held the full report and undertook to advise the meeting of all points requiring discussion.

3. FOCAS outlined the sequence of events in HMS EAGLE and detailed the conclusions reached by the Board of Inquiry on the possible cause of the fire. These were:

a. Seat of incorrect material

b. Acetylene contamination

c. Oil contamination

d. Grease contamination

e. Weakness in Hairline crack in system component.

4. Although the actual cause would probably never be known, it was possible that a valve with a nylon seat had been fitted in the Port GOX system since subsequent investigation revealed a nylon seated valve in the Stbd. plant and another in the on-board spares. Nylon was the alleged cause of previous fires in HM ships VICTORIOUS and ARK ROYAL in the early 1960's and action was taken at that time for all GOX valves in service to be modified to copper seats. Because of unsatisfactory wear characteristics copper seats were later replaced by monel seats which are currently fitted to all N35 valves. HMS ARK ROYAL confirmed that arrangements had been made for all N35 valves to be checked for correctness of material and that stools were being made to make the valves more readily accessible and therefore obviate strain when being operated. After discussion the following points were marked to be investigated:

a. Check if nylon seats used in N9 Air Valves are interchangeable with seats used in N35 valves and propose modification if necessary.

Action: Hale Hamilton

b. Investigate lubricant for GOX valves.

Action: DG Ships

c. Review materials for 'O' seals and means of positively identifying as suitable for oxygen service.

Action: DG Ships

d. Consider if only complete valves (cleaned ready for use) be carried as on-board spares. Valves only to be refitted by nominated Dockyard or Makers.

Action: DG Ships

5. DG Ships confirmed that the ROF Bridgewater had found all the EAGLE samples within the limit specified for acetylene and that this could be disregarded as a possible cause of the explosion. HMS ARK ROYAL confirmed that acetylene spot checks were taken every 24 hours when the plant is in production but that the prescribed tests on the storage tank had not been undertaken. Air Products confirmed that the existing instructions for the plant were satisfactory and that those for the storage tank were intended to apply to liquid stored for long periods without addition or dispensing. It was confirmed that it was not necessary to carry out a separate acetylene test when changing from LOX/GOX or vice versa. DG Ships undertook to investigate the requirement in DGS/TPSE/79 Chap. 4 for daily acetylene checks from the storage tank when the plant is shut down.

Action: DG Ships

6. The question of hydrocarbon contamination by oil or grease was discussed. HMS ARK ROYAL confirmed that lubricating oil consumption of refrigeration compressor and air compressors was monitored on start up. Air Products considered that clean cotton gloves should be worn when re-assembling components etc. in the LOX/GOX system to reduce possibility of contamination by sweat or grease. DG Ships agreed that this should be added to the existing instructions in DGS/TPSE/79.

Action: DG Ships

7. HMS ARK ROYAL confirmed that tests of compartment atmosphere and RS 500 cold box for presence of excess oxygen were carried out in accordance with instructions but that the LGSB plant did not have sampling points fitted. It was decided that since the LGSB cold box is continuously purged while running, with waste nitrogen product, normal compartment checks would be sufficient pending A & A action to fit the necessary tappings. Air Products stated that the Beckman Analyser is used by the R.N. was no longer used by them it having been replaced by the 'SERVOMEX' analyser. DG Ships agreed to investigate the possible issue of a Servomex to ARK ROYAL for evaluation.

Action: DG Ships

8. The recommendations of the Board to be implemented in HMS EAGLE included for the surfaces of storage cylinders, valves, gauges, junction boxes, etc., to be free of paint. Air Products did not specify any precautions regarding painting of their plant or storage vessels but non-ferrous valves, gauges, piping, etc. in a GOX system did not require paint protection and it was reasonable for existing paint on these items to be removed. DG Ships stated that this matter was under investigation at MOD(N) and that no action should be taken to strip GOX cylinders of paint pending the outcome of these enquiries.

Action: DG Ships

9. Consideration was given to the use of steel tools in LOX compartments. It was agreed that such tools should not be stored or kept in a LOX compartment but that there is no objection to use subject to satisfactory test of compartment atmosphere This would be added to relevant publications.

Action: DG Ships

10. Other actions resulting from the recommendations of the Board of Inquiry are as follows:

a. Preparation and issue of a LOX Compartment log to record safety tests and that regulations have been read and understood.

Action: FOCAS

b. Review of BR 1754 Chapter 18.

Action: DG Ships

c. Need for ARK ROYAL to be issued with means of verifying correct air flows through LOX compartment ventilation.

Action: DG Ships

d. LOX dispense point and GOX dispense points to be boxed in and made lockable when not in use.

Action: DG Ships

e. DGA(N) to verify tests necessary for 500 gall ditchable LOX tanks.

Action: DGA(N)

f. Need to emphasize hazards during training course at HMS SULTAN.

Action: SULTAN/Air Products

g. DGS/TPSE/79 to refer to need to operate GOX valves SLOWLY.

Action: DG Ships

ORIGINAL SIGNED BY

R. F. Pearce
for DIRECTOR GENERAL SHIPS
24 August 1971

REF: 1100/361/02/134

Distribution:

DGS: 122, 132, 134, 223, 242, 253; DGA(N); CED; FOCAS; C in C WF; HMA ARK ROYAL HMS SULTAN; CDL Devonport; Air Products Ltd.; Hale Hamilton (Valves) Ltd.

(Retyped 9/28/72 sba)

HAZARD LEVEL OF HYDROCARBON FILMS

IN

SYSTEMS CONTAINING LIQUID AND GASEOUS OXYGEN

E. Kehat

"This study was supported by the U.S. Air Force
under Contract No. AF 33 (616)-6730

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Air Products and Chemicals INC.
ALLENTOWN, PENNSYLVANIA

APCI DOCUMENT
NO. 19002323

HAZARD LEVEL OF HYDROCARBON FILMS

IN

SYSTEMS CONTAINING LIQUID AND GASEOUS OXYGEN*

E. Kehat

INTRODUCTION

The object of this work was to determine realistic standards of cleanliness in systems containing liquid and gaseous oxygen.

An arbitrary figure of 4 milligrams per square foot (1) had been set by examination of systems that had caused no trouble in the past. It was felt that this figure was too low and that experimental determination of the safe level should be made to set such standards.

Previous workers had tested high surface concentrations of oils, which were found to be highly explosive in liquid or gaseous oxygen and in high pressure air. Palmer (2) reported some work performed by Loison in 1952. A nominal 1-inch pipe, approximately 250 ft. long, with an oil film of 20,000 mg/sq.ft. (about 0.3 mm thick) and with air at a pressure of 100 psig was used. Upon ignition, a pressure wave was generated and the walls of the pipe were ruptured in a number of places.

*This study was supported by the U.S. Air Force under Contract No. AF 33(616)-6730.

Basyrov and Mikhedov (3) studied the detonation limits of some Russian lubricating oils solidified and dispersed in liquid oxygen at concentrations of 7.5 to 21% oil in LOX. For one type of spindle oil in a mixture of 15% oil in LOX, the detonation ability was similar to that of TNT.

Some unsystematic work had been done at Air Products, Incorporated, in 1956 and 1957 (4), on ignition of a variety of lubricants in air, oxygen, and liquid oxygen. The amounts of oil were substantial and powerful detonators were used. The sound of the detonation and a study of the surviving parts of the equipment indicated that the oil ignited in all tests. No quantitative data of the oil film concentrations were taken.

Based on these meager past experiments, the range of concentrations of interest for this study was taken as 4 to 20,000 mg/sq. ft.

EXPERIMENTAL

A n-hexadecane film was applied evenly to the surface of a clean section of pipe. The boiling temperature and the molecular weight of n-hexadecane are in the ranges for common lubricants; it is available at a purity of at least 95% and its concentration in solution can be determined with accuracy.

The pipe section (Figure 1 and 3) was 2 ft. of 1 inch schedule 40 stainless steel pipe with a 6-inch section of nominal 1/2 inch stainless pipe at each end. During gaseous oxygen runs, one end of the pipe was closed by a rupture disk made of 1.5 mill. brass foil in a modified 1/2 inch union. These disks were rated at 400 psig. A rupture disk that was rated at 2000 psig was used for the 1500 psig runs.

The hexadecane was applied to the surface from a solution in carbon tetrachloride, which was evaporated in a hot water bath while rotating the pipe section to achieve uniformity of the hydrocarbon film on the surface. Visual and tactile observation indicated that a reasonable degree of uniformity was achieved. The amount of hydrocarbon deposited on the surface was controlled by the quantity and concentration of the feed solution. The area covered was calculated to be 0.723 sq.ft.

Two ignition mechanisms were used.

1. The first mechanism was a high voltage spark. A Model T Ford ignition coil was used with an electrode made either from a length of nichrome wire in a compressed Teflon insulator, or a copper wire soldered to the tip of a spark plug. The electrodes were inserted at the middle of the pipe and the tip of the wire was maintained at a distance of 5 mm from the opposite pipe wall, which served as the grounding electrode. The power input to the spark coil was 5 to 12 watts.
2. The second mechanism used was an electric match, DuPont S-65 squib. The squib was stripped of its insulation, re-insulated with ceramic beads, and positioned at the end of the 1" pipe section. This squib releases 4 to 8 calories in about 20 milliseconds.

After application of the film, the pipe section was cooled to room temperature and the igniter and the oxygen line were connected. The pipe was then purged with oxygen for five minutes to remove the last traces of the solvent vapors. The rupture disk assembly was then tightened, the pipe was pressurized with oxygen, and ignition was instigated. The

same procedure was followed for the blank runs except that ignition was not started and the pipe was pressurized at 50 psig for five minutes.

The pipe section was then disassembled. The unburned hexadecane was dissolved in two 125 cc batches of fresh carbon tetrachloride and the combined solution was concentrated by evaporation of most of the solvent. The volume of the concentrate was measured and the concentration of the n-hexadecane in the concentrate was determined with a Beckman IR-4 infrared analyzer.

For the runs in liquid oxygen, the end sections were removed after deposition of the film and one end of the 1-inch section was capped (Figures 2, 4, and 5). The area of the section was calculated to be 0.548 sq. ft. The pipe was immersed vertically in liquid nitrogen contained in a stainless steel dewar. Gaseous oxygen was fed into the top of the pipe and liquid oxygen was condensed to fill about 80% of the volume. By using this condensation technique in contrast with previous experiments in which liquid oxygen had been poured into warm containers, only a small amount of oxygen was present in case a detonation would be initiated. Thick electrical insulation was used on the high voltage line and the pipe itself to prevent current leakage. Following ignition the pipe was removed and warmed slowly. The residual hexadecane was dissolved in carbon-tetrachloride, concentrated, and analyzed.

RESULTS

The results, plotted as surface concentration of hexadecane (mg/sq. ft. of pipe surface) against the percent recovery of the hexadecane, are given in Figures 6, 7, and 8.

Since all ignition work is poorly reproducible, a number of runs were made at each concentration and the results were plotted in a statistical form instead of showing the individual points. The plot for each concentration represents the 95% confidence limit of the results and was calculated by the relation $\bar{X} \pm \frac{2S}{n^{1/2}}$, where $\bar{X}$ is the average per cent of unburnt hexadecane recovered in all the runs at that concentration. $S/n^{1/2}$ is the standard deviation for these runs and n is the number of runs. The number of runs is also given on the plot. These data and the results of the individual runs are also given in Table I.

In Figure 6, the 95% confidence limit of all 11 blank runs is 99.3 ± 5.7. The spread of the ignition runs is greater, since a small area that burns under the igniter is not reproducible.

The infrared analyses of the hexadecane in the carbon tetrachloride were reproducible to 0.3 mg/cc. This uncertainty could cause a deviation of 2% in the recovery in the 1000 mg/sq. ft. range and a deviation of 15% in the 100 mg/sq.ft. range. This is the probable reason for the larger scatter of the data at lower concentrations.

At the highest surface concentrations used, there was not sufficient oxygen at 50 psig to burn all the hexadecane. The two broken lines on Figure 6 indicate the minimum recovery of hexadecane for the two concentrations, if all the oxygen at 50 psig is consumed in a stoichiometric ratio to form only CO_2 and H_2O as combustion products. Actually, some carbon is formed in all ignition runs and considerable amounts of carbon were found in the high concentration runs. In the two highest concentration runs at 6000 mg/sq.ft. a detonation wave followed the ignition. Subsequent runs were made at lower concentrations, as this concentration was in the detonation range.

Effect of Pressure

No significant effect was found in the range of 20 to 200 psig. In ten runs made at 1050 mg/sq. ft. and 1500 psig, the recovery was 83 $\pm$ 6%, compared to a recovery of 99 $\pm$ 3% for ten runs at the same concentration and pressures of 20 to 200 psig. Increased pressure is known (5) to decrease the ignition temperature of lubricating oils and the increased solubility of oxygen in the oil film probably helps to propagate combustion.

Effect of Ignition Mechanism

Combustion properties of the system hexadecane-oxygen were estimated from the literature (6, 7, and 8). The quenching distance was estimated to be less than 4 mm, therefore, the sparking electrode was kept at a distance of 5 mm. from the wall. The minimum ignition energy was estimated to be 6×10^{-3} cal The ignition energy of both ignition mechanisms used was considerably higher. The energy of the spark was of the same magnitude as friction or impact effects that are possible sources of ignition in a pipe system. The rate of application of the ignition energy of the electric match is several orders of magnitude greater than that of the spark. There is, however, no way of directly comparing different ignition mechanisms. It is very unlikely though that self-ignition in a LOX system will be instigated by a source as powerful as an electric match.

The data in Figure 7 on the results of ignition by an electric match show no marked significances from the data in Figure 2, except for poorer reproducibility. Possibly more hexedecane directly under the squib was burned.

Effect of Temperature

In about one-fourth of the runs using spark ignition, the tube was deliberately not allowed to cool after evaporation of the solvent. The temperature of the pipe was 30 to 40 degrees

Centigrade above ambient temperature. No effect of temperature in this range was found.

At liquid nitrogen temperatures, the hydrocarbon film on the surface of the pipe freezes, and a small amount of film flakes off. The frozen oil, being less dense than the LOX, floats to the surface creating an increased hazard.

Blank runs were made to evaluate the magnitude of this effect. The freezing, flaking, and floating mechanism was not large below concentrations of 500 mg/sq.ft. (Figure 8).

In the liquid oxygen runs, the inside of the pipe was observed before and after ignition. At a hexadecane concentration of 1000 mg/sq.ft., a bright ring about 2 inches long, symmetrical about the sparking electrode, was observed. This indicated that ignition had started but did not propagate. No such rings were observed in the blank runs. At lower concentrations, small patches of clean areas were observed under the electrodes after ignition but no continuous burned region was evident.

Effect of Lubricant Flow

At surface concentrations of over 1000 mg/sq.ft., some mobility of oil on the surface was observed. It seemed likely that at high surface concentrations some of the film would flow to the lowest parts of the system, accumulate, and increase the ignition hazard at that location.

Some experiments were made to determine the concentration level at which this effect becomes pronounced. A tray was constructed from a 3/16-inch flat stainless steel plate (0.80 sq.ft. surface area). Thin walls were connected, using an epoxy resin adhesive.

The surface was coated successively with 100, 250, 500, 1000, and 2500 mg/sq. ft. of n-hexadecane by applying predetermined amounts of 20 mg/cc solution of hexadecane in carbon tetrachloride. The solvent was evaporated using an infrared lamp. Smear tests were made at each concentration by rubbing a finger on the surface and observing reflected light from the surface. No smearing was observed at 100 and 250 mg/sq. ft. Slight smearing was observed at 500 mg/sq. ft. Smearing was considerable at 1000 mg/sq. ft. and at 2500 mg/sq. ft., it was possible to push the oil on the surface.

Safe Concentration Level

From Figures 6, 7, and 8, it would seem that a hexadecane level of 1000 mg/sq. ft. can be tolerated for gaseous oxygen and a slightly lower level than 1000 mg/sq. ft. can be tolera for liquid oxygen. Flaking of the lubricant in LOX, and film flow at ambient temperature, reduce the safe level to about 500 mg/sq. ft.

In liquid oxygen, floating frozen oil will flow with the LOX and accumulate at dead ends downstream. In gaseous oxygen, flowing films will collect at low levels. Sampling of lines for lubricant contamination should therefore be made at the lowest levels in ambient temperature lines, and at low velocity zones in liquid oxygen systems.

The recommended safe level contamination with hydrocarbons with viscosity and vapor pressure similar to hexadecane is 100 mg/sq. ft.

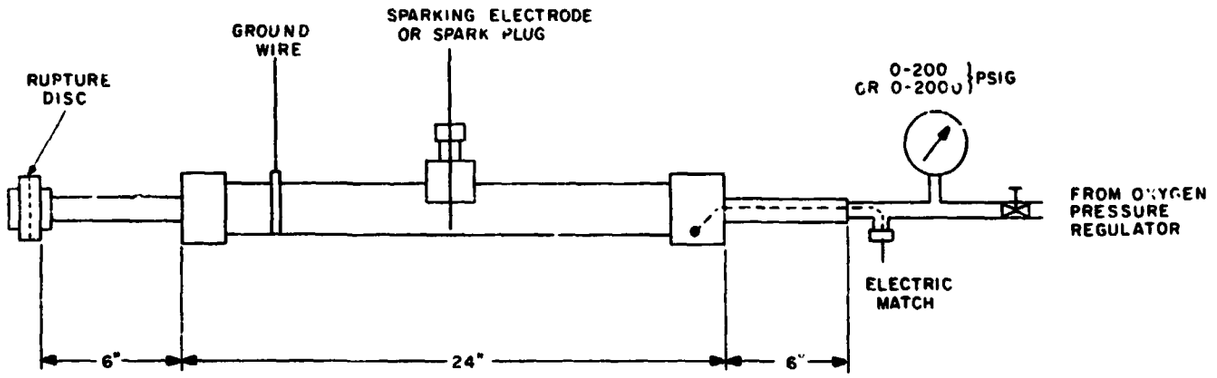


Figure 1. Ignition Apparatus Using Gaseous Oxygen.

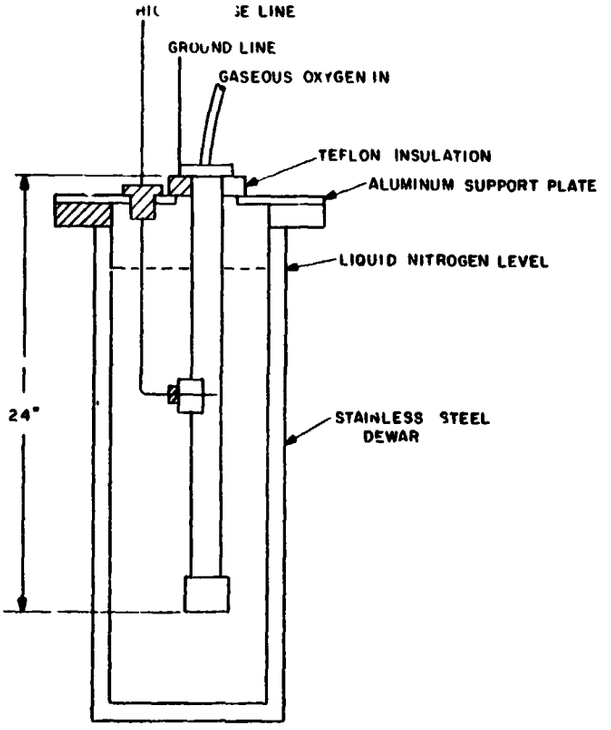


Figure 2. Ignition Apparatus Using Liquid Oxygen

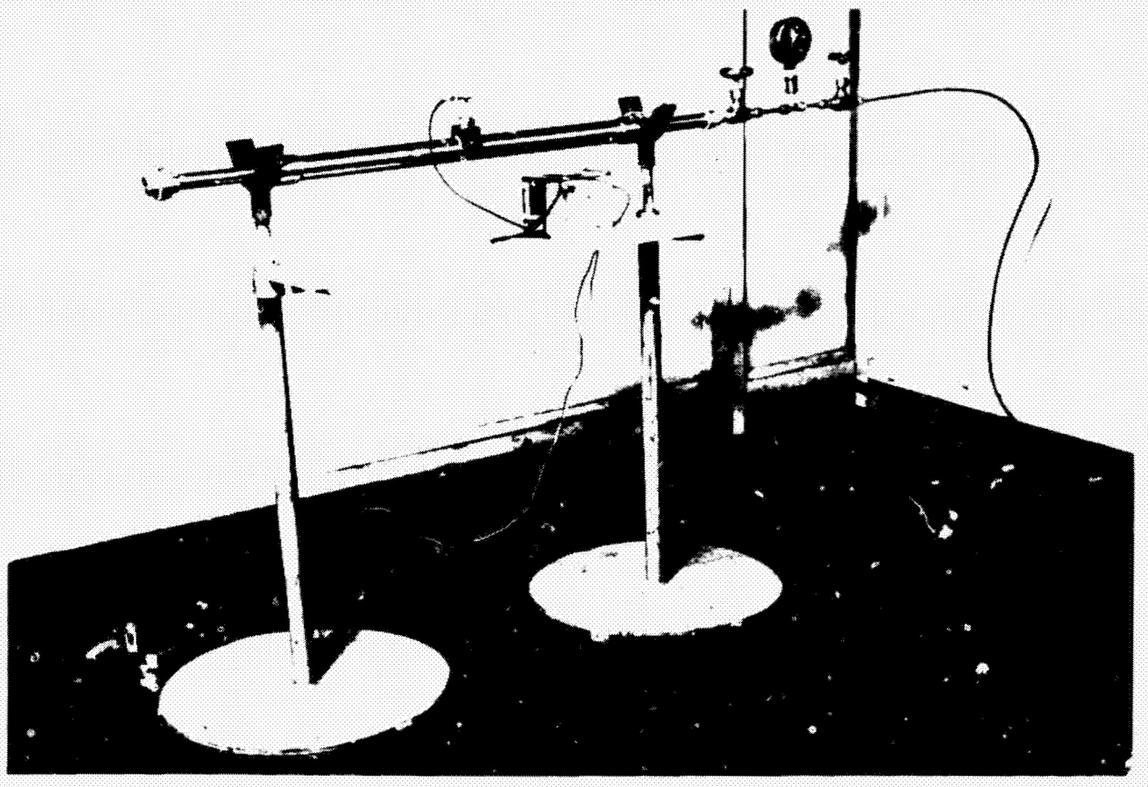


Figure 3. Ignition Apparatus Using Gaseous Oxygen

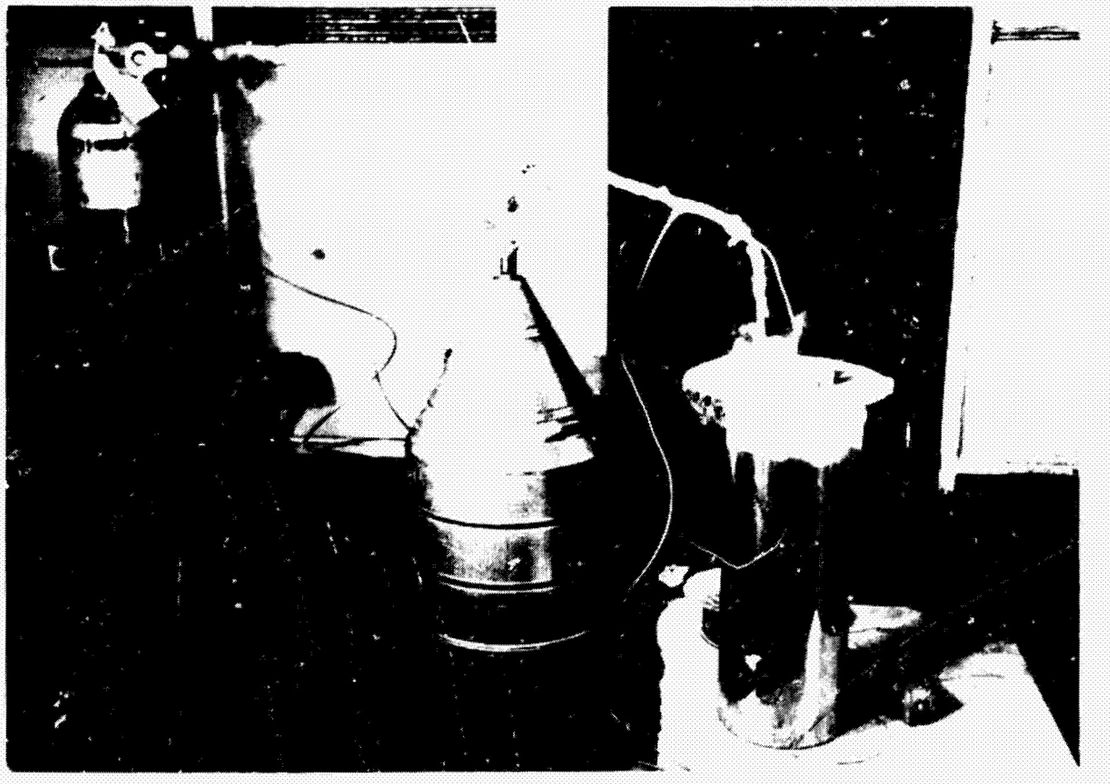


Figure 4. Ignition Apparatus Using Liquid Oxygen Before Ignition

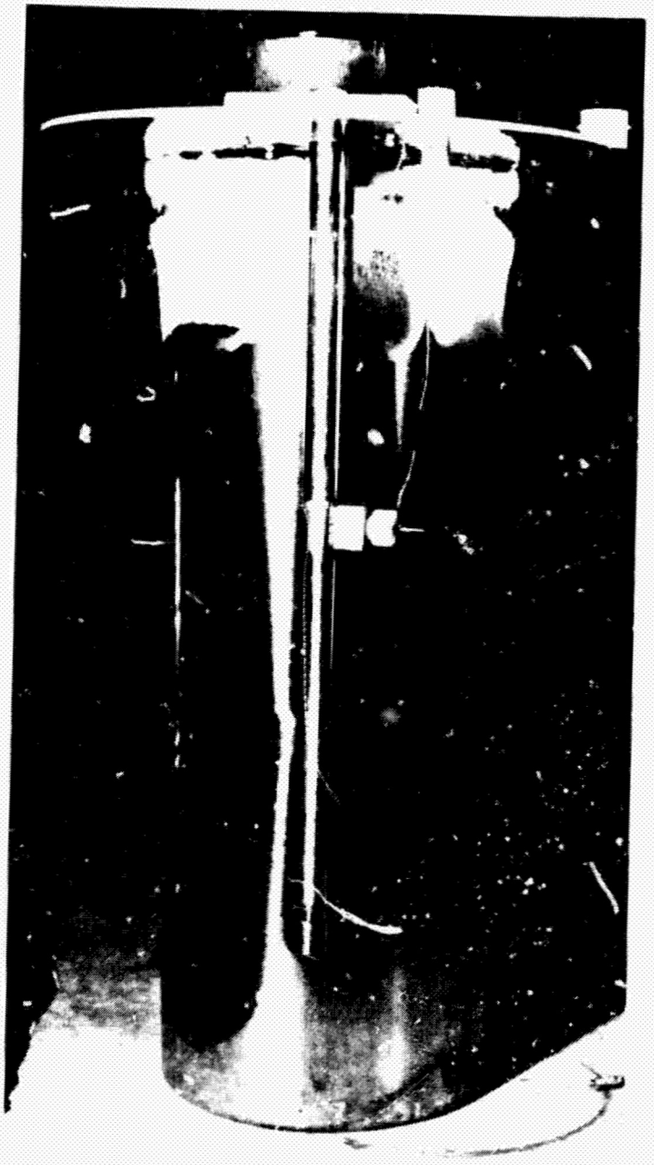


Figure 5. Ignition Apparatus Using Liquid Oxygen After Ignition

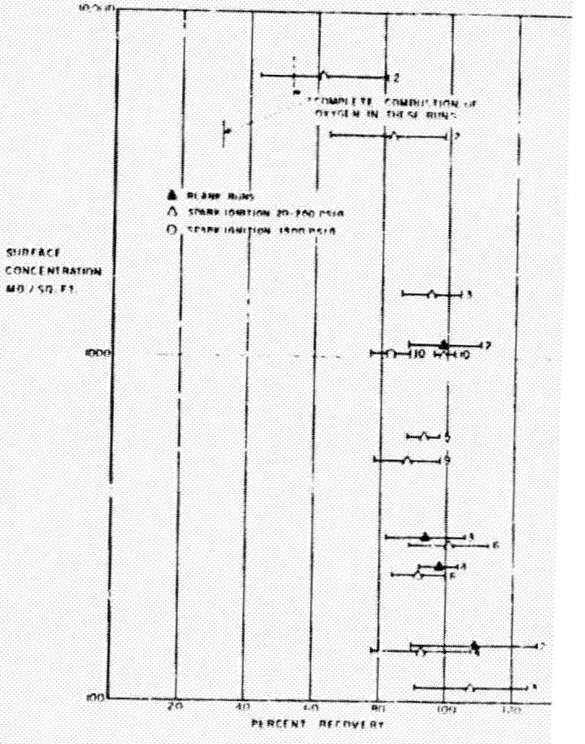


Figure 6. Unbonded Hexadecane Films After Spark Ignition in Gaseous Oxygen

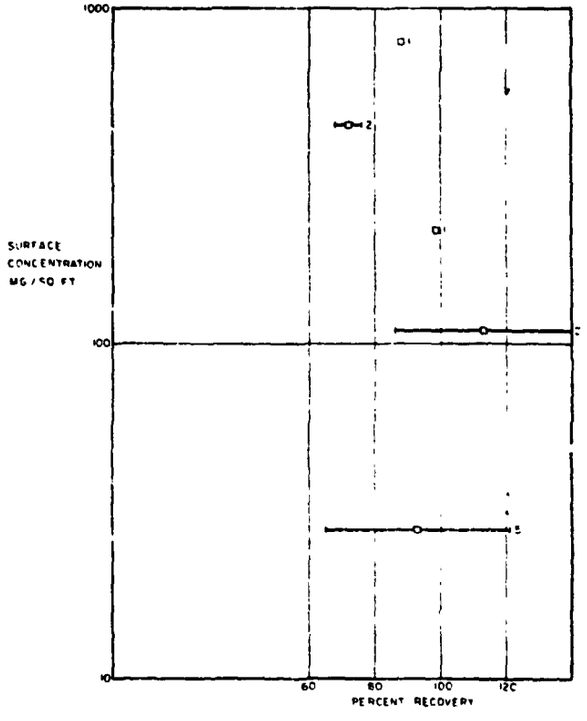


Figure 7. Unburned Hexadecane Films After Ignition with an Electric Match in Gaseous Oxygen Under 200 PSIG Pressure

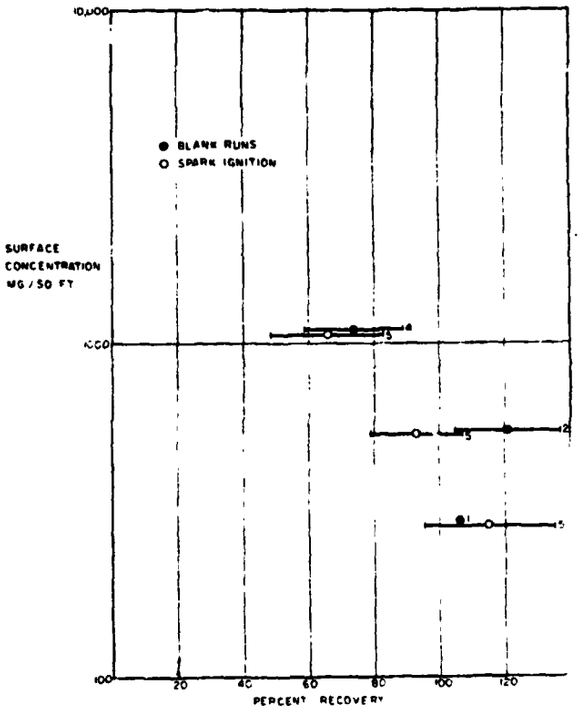


Figure 8. Unburned Hexadecane Films After Spark Ignition in Liqu Oxygen

TABLE I. EXPERIMENTAL RESULTS

Surface Concentrations mg/sq. ft.	Oxygen Phase	Pressure psig	Igniter	No. of Runs	Recovery Percent	95% Confidence Level for Recovery
145	Gas	50	Blank	2	100, 119	109 ± 19
240	Gas	50	Blank	4	100, 93, 93, 106	98 ± 6
290	Gas	50	Blank	3	103, 82, 97	94 ± 12
1050	Gas	50	Blank	2	94, 105	99 ± 11
110	Gas	200	Spark	3	93, 108	108 ± 17
		50	Spark		123	
145	Gas	50	Spark	4	80, 111, 80, 100	93 ± 15
240	Gas	50	Spark	6	86, 92, 102, 89, 103	92 ± 8
290	Gas	50	Spark	6	122, 90, 112, 86, 89, 109	101 ± 12
500	Gas	200	Spark	9	82, 85, 97	88 ± 10
		50	Spark		86, 64, 77, 91, 95, 116	
580	Gas	50	Spark	5	93, 85, 100, 92, 97	93 ± 5
1050	Gas	200	Spark	10	88	99 ± 3
		100	Spark		100.5, 101.5	
		50	Spark		99, 97, 100, 106, 106	
		20	Spark		98, 99	
1050	Gas	1500	Spark	10	Original data unavailable	83 ± 6
1520	Gas	50	Spark	3	88, 93, 103	95 ± 9
4400	Gas	50	Spark	2	74, 92	83 ± 18
6500	Gas	50	Spark	2	53, 72	62 ± 19
28	Gas	200	Electric Match	5	61, 70, 84, 108, 143	93 ± 28
110	Gas	200	Electric Match	2	99, 127	113 ± 28
220	Gas	200	Electric Match	1	99	
450	Gas	200	Electric Match	2	70, 74	72 ± 4
800	Gas	200	Electric Match	1	88	
274	Liquid	-	Blank	1	106	
584	Liquid	-	Blank	2	113, 129	121 ± 16
1096	Liquid	-	Blank	4	76, 61, 94, 63	74 ± 15
274	Liquid	-	Spark	5	128, 143, 101, 120, 85	115 ± 20
584	Liquid	-	Spark	4	72, 81, 99, 113, 99	93 ± 14
1096	Liquid	-	Spark	5	85, 55, 48, 54, 89	66 ± 17

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W. L. Ball
L. G. Frederick
D. R. Latshaw
C. McKinley
H. H. Master
W. W. Schmoyer
R. D. Paige

Air Products and Chemicals INC.

ANALYTICAL REPORT

AUG 13 1971

R & D DEPT.

DATE: 8/13/71
LAB. NO.: See Below
Lab. Book: 1739

SAMPLE OF: Viton O-Ring Material (2 samples)
FROM: Safety Dept.

SAMPLING DATE: **REQUESTED BY:** **SAMPLED BY:**
ANALYSIS REQUESTED: Oxygen Index Rating

ANALYTICAL METHOD: Oxygen Index Test
ANALYST: L. G. F. **IWO NO.:** XD-0128 **PROJ. NO.:** **R&D PROJ. NO.:**
REMARKS:

ANALYSIS

The recently constructed Oxygen Index Test apparatus was used in determining the "n" values for the samples submitted for testing. The Oxygen Index (n), of a material, is the percentage concentration of oxygen in a mixture of oxygen and nitrogen which will maintain equilibrium burning conditions, i.e., the heat produced during combustion just balances the heat lost to the surroundings. Physically, this is the lowest concentration of oxygen which will support sustained combustion of the material, and is calculated from the following equation:

$$n(\%) = \frac{100 \times O_2}{O_2 + N_2}$$ where O_2 is the oxygen concentration at equilibrium and N_2 is the associated nitrogen concentration.

The ideal combustion rate is 180 seconds to burn a distance of 50 mm. If the sample does not burn 50 mm in 180 seconds, the oxygen concentration is too low, and if the sample burns the 50 mm. in less than 180 seconds the oxygen concentration is too high.

Below are the results of the materials tested as well as a comparison of other gasketing materials.

Material	n (% O_2)	Time-Sec	Length of Burn	Remarks
Viton E 60	35	--	--	No Ignition
(green)	45	15	--	Went out
Lab. No.	55	167	50 mm	
71-344	54	180	35 mm	
Samples were	56	185	50 mm	
cylindrical in shape				
5 mm diameter	n = 56			Ash dropped off in 1/2" sections and
3" long				was green in color.

APCI DOCUMENT NO. 29000304

Material	n (% O_2)	Time-Sec	Length of Burn	Remarks
Viton A	56	188	50 mm	Some visible combustion of gases
(black)	57	181	50 mm	before the flame.
Lab. No 71-345	57	180	50 mm	
Samples were cylindrical in shape				
3/16" diameter	n = 57			
3" long				
Garlock-900	24	150	50 mm	
	25	129	50 mm	
Samples were	23	160	50 mm	
rectangular	22	20	-	went out
in shape	23	167	50 mm	
1/8" thick	22	10	-	went out
1/4" wide				
3 1/4" long	n = 23			Sample produces considerable amount of carbon during burning
Johns-Manville	50	60	50 mm	Too High O_2 concentration
Asbestos #61	25	117	50 mm	
Sheet	20	15	-	Went out
	22.5	140	50 mm	
Samples were	24	151	50 mm	
rectangular in	25	150	50 mm	
shape	23	52	-	Went Out
1/8" thick				
1/4" wide				
3 1/4" long	n = 24			Some samples showed a tendency to go out close to the n value during the test. Sample produces considerable carbon during burning

Prepared by Lowell C. Frederick

Approved by David R. Latshaw
David R. Latshaw

LGF/

Air Products and Chemicals INC

OXYGEN COMPRESSOR VITON A

by

K. H. Nissler

DEMAG KA-27-IV/KA-4-IV

DEMAG Letter to APCI, 1P

August 11, 1971

APCI DOCUMENT NO 99000305

W. L. Bull
L. G. Frederick
D. R. Latshaw
C. McKinley
H. H. Master
R. D. Paige
W. W. Schmoyer

Air Products and Chemicals INC.

ANALYTICAL REPORT

RECEIVED
AUG 19 1971
R & D DEPT.

DATE: 8/17/71
LAB. NO.: 71-379
LAB BOOK: 1739

SAMPLE OF: Silicone O-Ring (1/8" Dia.)
FROM: Safety Department

SAMPLING DATE: REQUESTED BY: R. D. Paige SAMPLED BY:
ANALYSIS REQUESTED: Oxygen Index Rating

ANALYTICAL METHOD: Oxygen Index Test
ANALYST: L.G.F. IWO NO.: XD-0128 PROJ. NO.: R&D PROJ. NO.:
REMARKS:

ANALYSIS

The sample submitted for testing was tested in the same manner as the previous Viton O-Ring materials which had Oxygen Index values determined (Analytical Report 71-344, 71-345, Viton-O-Rings, 8/13/71). The results of the present test are as follows:

Material	n (% O_2)	Time-Sec.	Length of Burn	Remarks
Silicone O-Ring	20	180	42 mm	
1/8" Dia. - 3" long	21	180	50 mm	
Lab No. 71-379	*21	180	49 mm	
Cylindrical Shape	22	175	50 mm	
	23	166	50 mm	

n = 21

* Stock sample was tested in same manner as received.
All other samples were cleaned with methylene chloride.

The ash remained intact during the entire burn. The ash cross section showed two distinct layers. The ash was very brittle and it had a gray-white color. The sample produced considerable smoke during burning.

Prepared by Lowell G. Frederick
Lowell G. Frederick

Approved by David R. Latshaw
David R. Latshaw

LGF/plr

APCI DOCUMENT NO. 2000306

Air Products and Chemicals, Inc.

PUT IT IN WRITING

Date June 3, 1971

To Distribution

Subject Minutes of CGA Air Separation Equipment Committee held at Ft. Lauderdale, Florida May 11-12, 1971

From W. L. Ball

( ) Take Action ( ) For Your Approval ( ) For Your Info ( ) Discuss With Me

( ) For Your Comments ( ) As Requested ( ) File ( ) Note & Return

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Enclosed for your information are the minutes of the meeting of the Compressed Gas Association Air Separation Equipment Committee held May 11 and 12, 1971 at Fort Lauderdale, Florida.

These minutes are a composite of the notes made by Dr. McKinley, Bruce Berrettini, Russ Stompler and Leonard Ball who represented Air Products at the meeting.

Liquid Oxygen Pumps
Aluminum in Oxygen Service
Liquid Carbonic Liquid Oxygen Trailer - Resident Victory Memorial Hospital
May 1970.

L Ball

mr
enc.

APCI DOCUMENT NO. 99000307

FIRES IN CENTRIFUGAL LIQUID OXYGEN PUMPS

A. GEAR DRIVEN PUMPS

Pump Mfr.	Suction Filter	RPM	Impeller Size	(*) Bronze Impellers Reaction	Probable Cause
Burkhardt	No	9,500	4.5	Cold End Exploded	Bearing Failure
Burkhardt	?	9,500	4.5	Not Certain	Not Certain
Burkhardt	?	9,500	4.5	Cold End Exploded	Bearing Failure
Burkhardt	?	9,500	4.5	Cold End Exploded	Bearing Failure
Cryostar	?	9,500	4.5	Cold End Exploded	Bearing Failure
Cryostar	?	9,500	4.5	Impeller & Seal Burned	Not Certain
Cryostar	Yes	9,500	4.5	Cold End Exploded	Faulty Repair
Cryostar	No	9,500	4.5	Cold End Exploded	Contaminant
Airco/Paul	Yes	9,500	4.5	Gear Box Fire	Faulty Repair
Airco/Paul	Yes	9,500	4.5	Gear Box Fire	Faulty Repair
Airco/Paul	Yes	9,500	4.5	Cold End Exploded	Faulty Repair Bearing Failure
Airco/Paul	Yes	11,200	4.5	Cold End Exploded	Bearing Failure
Airco/Paul	Yes	13,100	4.5	Cold End Exploded	Bearing Failure
Airco/Paul	Yes	15,800	4.5	Cold End Exploded	Lubricant and Bearing Failure
Airco/Paul	Yes	15,800	4.5	Cold End Exploded	Not Certain
J. C. Carter	No	8,000	5.6	Cold End Exploded	Faulty Repair
Airco/Paul	No	7,200	6	Cold End Exploded	Bearing Failure
Airco/Paul	Yes	9,500	6(*)	Cold End Exploded	Bearing Failure
Airco/Paul	Yes	9,500	6	Cold End Exploded	Bearing Failure
Airco/Paul	Yes	9,500	6	Cold End Exploded	Bearing Failure
Airco/Paul	Yes	9,500	6	Cold End Exploded	Bearing Failure
Airco/Paul	Yes	9,500	6	Cold End Exploded	Not Certain
Airco/Paul	Yes	9,500	6	Internal Fire (Volute)	Not Certain

Cosmodyne	No	8,400(2 Stage)	4.5 & 6.0	Cold End Exploded	Lubrication and Bearing Failure
Cosmodyne	No	8,400(2 Stage)	4.5 & 6.0	Cold End Exploded	Foreign Contaminant

SUBTOTAL 25

(14) Due to Bearing Failure

(4) Not Certain

(5) Faulty Repair

(2) Contaminant

FIRES IN CENTRIFUGAL LIQUID OXYGEN PUMPS

A. BELT DRIVEN PUMPS

(*) Bronze Impeller(s)
(*) (*) Bronze Impeller & Volute

Pump Mfr.	Suction Filter	RPM	Impeller Size	Reaction	Probable Cause
Turbocraft	?	5,500	6"	Belt Box Fire	Seal Leak - Belt Rub
Turbocraft	No	8,500	4.67"	Cold End Exploded	Faulty Repair and Operation

SUBTOTAL 2

(1) Seal Leak

(1) Faulty Repair & Operation

B. CLOSE COUPLED PUMPS

Byron Jackson	?	3,600(10 Stage)	10"(*)	Internal Fire	Hydrocarbons
Byron Jackson	Yes	3,535	7 1/4"(?)	Motor/Bearing Explosion	No Slinger-Seal Leak DC 33 Grease
Lawrence	No	1,750	11"(*)(*)	Pillow Block Bearing Exploded	Improper Shrouding of Pump-Seal Leak
J. C. Carter	Yes	3,560	9"	Seal Fire	Seal Rubbing
J. C. Carter	No	3,560(3 Stage)	7 1/4"(*)	Seal Fire	Ran Dry (Unattended)
J. C. Carter	Yes	3,560	9"	Seal Fire	Seal Rubbing
J. C. Carter	No	3,560(2 Stage)	7 1/4"(*)	Seal Fire	Seal Rubbing
J. C. Carter	No	3,560	5 1/4"	Motor/Bearing Explosion	Improper Shrouding of Pump - Seal Leak
J. C. Carter	No	3,560(3 Stage)	7 1/4"(*)	Pump Explosion	Foreign Contaminant
J. C. Carter	No	3,560	5 1/4"	Seal Fire	Seal Rubbing
Paul	Yes	3,560	10 1/2"	Motor/Bearing Explosion	Seal Leak - Bearing Lubricant (Bad Design

SUBTOTAL 11

(4) Bearing Explosions, 3 of which were human error.

(5) Seal Fires, (1) Due to running dry.

(?) Contaminants

SUMMARY OF REPORTED INCIDENTS:

(14) Due to bearing failure on gear driven high speed pumps.

(10) Due to faulty repair, operation and/or installation.

(4) Contamination entering pump.

(5) Seal rubs & fires.

(1) Belt box fire due to seal leak.

(4) Not certain.

TOTAL 38

AGENDA FOR CGA-ASEC MEETING - MAY 11-12, 1971

1. Noise Pollution - 9:00 AM, Tuesday, May 11th

   Speakers - G. M. Diehl, Ingersoll Rand
   C. Duer, Burgess Manning

   The planning committee was fortunate in arranging for Messrs. Diehl and Duer to speak at our meeting. Both come highly recommended and their wide experience with industrial noise problems will add much to the meeting.

   Those attending should be prepared with questions and comments relating to their own experiences with regards to noise problems associated with compression equipment in particular, and air separation plants in general.

2. Liquid Oxygen Pumps - 9:00 AM, Wednesday, May 12th

   Speakers - C. J. Dorf, Linde
   Dr. C. McKinley, A. Products
   C. Saacke, Airco
   R. Sinclair, NCG

   The session will revolve around the questionnaire on liquid oxygen pump fires issued in February. The speakers are from within the air separation industry and as such are highly qualified to speak on problems encountered with liquid oxygen pumps. However, all attendees are expected to share any appropriate information they may have on the subject so that the meeting will be as meaningful as possible. The use of slides and handouts is encouraged.

3. Aluminum In Oxygen Service

   3.1 A review of the trailer incident at Victory Memorial Hospital in Brooklyn, in May of 1970 is scheduled, pending issuance of the investigation report by the National Transportation Safety Board.

   3.2 The general subject of using aluminum in oxygen service will be explored.

4. General

   4.1 Nov. 9-11 Oxygen Compressor Symposium

   This symposium has been structured to consider the general subject of how to compress oxygen safely. As such, it should be expecially interesting to the air separation industry.

4.2 1972 Plans

The meeting should be prepared to discuss future plans for the Air Separation Committee. Such things as meeting types, timing, direction, etc., will be scrutinized.

CGA AIR SEPARATION EQUIPMENT COMMITTEE MEETING

May 11 & 12, 1971

The CGA Air Separation Equipment Committee held its latest meeting May 11 & 12, 1971 in conjunction with the CGA Industrial Gas & Related Products Divisional meeting at Fort Lauderdale, Florida. The agenda for the first day included discussion of noise problems, particularly as related to air separation plants and the large rotating equipment. The second day continued discussions of past meetings with regard to liquid oxygen pumps. The agenda for the meeting is attached.

MAY 11 - Mr. George Diehl, a noise specialist with Ingersoll Rand, Phillipsburg, New Jersey, began the discussion on plant noise with a prepared presentation of the action being taken by his company in reducing the noise produced by rotating equipment and a general discussion of noise control in a producing facility. Because of the recent federal regulations, Ingersoll Rand is now working on reducing the noise output on all of their products by evaluating and changing, as necessary, basic machinery design. Mr. Diehl, in the past year, prepared a series of lectures which were given to all of the Ingersoll Rand design engineers. These lectures covered the basic information with regard to noise, what it is, how it is produced, and how it can be controlled with emphasis being placed on design techniques for reducing the noise generation. It is his contention that considerable reduction in noise can be made with little or no increase in cost. He cited, as an example, their air compressor design used in construction in which the noise output has been reduced to a "whisper". With larger machines, of course, the problems become more difficult. This series of lectures is now being published, one at a time, in their monthly magazine, "Compressed Air" and will later be collected into a small book.

A number of design features may contribute to the noise produced by a compressor; these include wheel design, number of vanes, rotational speed, gear design, weight and design casing and gear box, mounting design, design of piping and valves in associated piping, and horsepower. While the purchaser can reduce operator exposure to noise by such measures as lagging, silencers, and location of unit within the plant or building, internal design is set by the manufacturer and noise reduction in this area must be made in the basic design stages. As a rule of thumb, doubling the horsepower usually increases the noise level from 4-5 db (a 3 db noise increase is equal to doubling the noise level). The noise level that can be expected by a horsepower increase is roughly equal to -

$$17 \log_{10} \frac{HP_2}{HP_1}$$

where HP_1 is horsepower of reference compressor for which the noise level is known.

HP_2 is horsepower of compressor for which the estimated noise level is required.

Fluid turbulance caused by rotor rotation is another important producer of noise. The rotational speed of the rotor is much more important than the tip speed. An increase of the noise level caused by increase of rotational speed can be estimated by the formula -

$$50 \log_{10} \frac{n_2}{n_1}$$

where n_1 is rotation speed of compressor for which the noise level is known.

n_2 is the rotational speed of the compressor for which the estimated noise level is required.

A slight rotational imbalance may cause resonance in the compressor structural member which can produce undesirable noise. In this respect, the compressor mountings and foundations and velocity of flow through the compressor and associated piping become important factors in the design analysis to reduce noise.

Sound test codes are being prepared for inclusion in the existing ANSI S5.1, the test code for compressors. In preparing a noise specification for new equipment, it is important to specify whether the noise tests are to be made at the manufacturer's plant or at the customer's site where the machine will be installed. Since the addition of two noise producing sources (for example a new compressor to an existing facility) each of which individually may be within acceptable limits, when combined may increase the total noise level to undesirable levels, a complete analysis of the plant environmental noises, plus the noise produced by the new machine, must be made. The exact location of the new machine within a plant, for example, whether the machine is outdoors or inside a building, or if inside a building, its exact location within the room must be considered. It was pointed out that there is a marked difference in the noise level produced if the noise source is positioned in the center of the room well off the floor, in the center of the room at floor level, up against one side wall, or in a corner of the room, with the noise produced increasing markedly in the above progression from the center of the room to the corner.

Mr. Diehl discussed various noise sources in a typical compressor installation and basic approaches for control of the noise. These included:

	location	cause of noise	control
1.	valve & piping	fluid velocity	lagging
2.	expansion joint	fluid velocity	lagging
3.	coupling	air around coupling	enclosure
4.	driver noise	cooling air & fan noise	enclosure or lagging
5.	rotor	fluid turbulance, rotor speed, ratio & position of rotating vanes to stationary vanes	internal design
6.	gear box	gear contact	enclosure or lagging
7.	cavity under machine	resonance	design

At Ingersoll Rand test areas where noise levels are excessive only when a machine is being tested, hearing protectors are worn only during the test period. At this time, red lights are used to warn all personnel that the

wearing of hearing protection is required. This is a possible solution where the operation of noisy equipment is intermittent.

The discussion emphasized the fact that manufacturers are turning their attention to the reduction of noise produced by the operation of heavy equipment. Also, that the buyers need to include in their purchase specifications for new machinery their requirements regarding the noise levels expected and permissible. These requirements must take into consideration the background noise levels of the environment in which the new machine will operate. While it may not be possible in large machines to reduce noise to a "whisper" as Ingersoll Rand has been able to do with their small air compressor, appreciable reduction in noise levels can be obtained by the design technology now available.

Mr. Charles Duerr, of Burgess Manning, presented a general discussion on noise and some of his experiences in reducing noise levels in practical situations. He noted that the noise criteria for a plant should be based upon desired noise levels where the operator will have to be, not necessarily where the noise is generated. In surveying a plant and identifying noise sources one must get very close to the noise generating source to positively identify it. Three feet away is too far, as noises from other locations may interfere. One must be only a few inches away from the suspected area to differentiate between sources. In actual situations, primary noise sources must be eliminated or reduced first before a general program can be instituted. A cyclical noise is more stressful than a low frequency noise.

Low frequency noises cannot be handled by the use of lagging but can be reduced substantially by the use of snubbers. Burgess Manning snubbers, with their internal perforated tubes, are designed on the principles of fluid flow rather than on acoustical criteria. These units create a variable impedance which is very effective in reducing flow variations and noise on reciprocating compressor installations. In a piping system, silencers should be installed immediately downstream of a noise producer, which solves the noise problem downstream until another noise source is encountered. This will prevent noise from radiating to the other equipment where it may be amplified or reflected. Lagging may be required on the exterior shell of a silencer to control the noise that may be radiated from the metal shell. Although some noise is radiated along or in the piping walls, the major carrier is the gas stream itself.

With regard to vent silencers, the more rigid the absorbative material the more susceptible it may be to being destroyed by the energy of the sound. Once the system is cracked, damage will progress until the entire system is destroyed. It was noted that acoustical materials are most effective in the mid frequency range. At high frequencies, a change of direction similar to a light trap may be quite effective.

Surrounding equipment and structures may have a marked effect on the propagation of noise and the intensity of noise along the sound path. Sound waves in air are similar to waves in water. Low frequency waves will tend to wash around and over obstructions while high frequency waves will tend to be blocked by an obstruction. Thus, depending upon the frequency, a structure between the noise source and the observer may have an appreciable effect as to intensity of the noise observed.

Mr. Duerr observed that, with regard to the lagging of pipe, 2 to 3 inches of fiberglass, packed to a density of 6 pounds per cubic foot and covered with 24 gauge steel sheet, is very effective. The fiberglass without the steel or the steel without the fiberglass offers almost no improvement in noise reduction. The benefit is a function of the weight of material per square foot and 1 pound per square foot offers about optimum benefit. It is, of course, important that there must be no contact between the pipe and the metal septum, otherwise noise will leak through the metal septum and be radiated. This can actually increase the emitted noise level in some instances. Leaded vinyl, although more expensive, is very effective. This material can be hung as a drape or used to wrap over fiberglass in the same manner as the metal septum noted above.

MAY 12 - This entire day was spent discussing the industries' liquid oxygen pump accident history and each companies' philosophy with regard to design and operation. Each company represented had prepared reports of each of their pump failures and reviewed their history in detail for the benefit of the committee members. Copies of the individual accident reports presented and an analysis of these reports is attached.

NCG reported that they have changed all their centrifugal LOX pumps to their new safety configuration. This includes:

1. Opening up clearance
2. Installation of bronze stops & wear rings
3. Changing seal design so that a bronze ring will take rubs
4. Inlet filter screens

NCG also stated that their piping design includes a manual shutoff valve near the liquid tank some distance from the pumps themselves.

Linde reported that their specifications for new pumps includes the use of bronze stops and wear rings and the use of monel bellows on the seals. They particularly avoid possible stainless to stainless rubs in the seal area. The Linde upgrade program on existing pumps includes the use of bronze impellers although their specifications for new pumps still includes aluminum wheels. Linde has approximately 1,000 pumps in operation on trucks and ground installation. Their failures in the past 10 years have all been with centrifugal units. Of the 9 failures reported, 5 were single stage units, 2 were 3 stage, and 1 was 2 stage. Eight of these units were operatin at 3700 rpm, the other failed unit operated at 7200 rpm. Other details reported included:

1. all units had aluminum volutes,
2. 7 had aluminum impellers, 2 had bronze impellers,
3. 8 had stainless steel shafts, 1 had monel,
4. 6 failures were attributed to rubbing in the shaft seal area,
5. 2 failures were attributed to bearing explosions involving seal leaks,
6. 1 failure involved a bearing failure resulting in internal rubbing and ignition.

Linde has approximately 250 older turbine units of their own design. They have no record of fires with these units. These turbine units operate at low head, and at 1700-2200 rpm. The housings are cast iron, impellers are stainless steel. These units are equipped with internal bearing using LOX safe lubricant (a Halocarbon or equal lubricant). Linde's design includes inlet filters on liquid oxygen pumps.

Linde also reported a failure of a nitrogen pump which was attributed to misoperation by the operator. The piping design was such that the Carter pump which failed could be supercharged by a turbine pump. The two pumps were separated by about 120' of 2" line. It is believed that the interconnecting line was not precooled properly and with startup of the turbine pump flash vaporization of liquid occurred in the line resulting in build-up of pressure to about 1100 psi. This resulted in overpressurization and failure of the Carter pump case.

The Airco program for safe operation of trailer mounted LOX pumps includes:

1. bronze stops and wear rings,
2. bronze impellers would be preferable although aluminum impellers are being used,
3. pump inlet screens, 12 mesh (1/16" openings),
4. elimination of combustibles in the trailer control cabinet,
5. the operator must stand away from the pump when operating,
6. in tanker service the pump inlet should not point toward the tank since, if a combustion failure occurs, flame & material from the inlet will impinge on the tank shell,
7. piping design must include an emergency shutoff valve with fusible links for automatic operation in the event the operator is unable to reach the valve.

Airco emphasized the fact that if a pump fire occurs there is a good possibility it will be at a customer plant and will, therefore, expose third party personnel and property. A discussion of the New Orleans fire which resulted in a $4 million loss was presented as a case in point. During the pump cooldown, the operator had jogged the pump to make sure it was free. After cooldown was completed, the operator turned to open the inlet valve when he heard an explosion. At this point, the pump had not been started. When he saw a cloud of "dark, dirty smoke" pouring out of the back of the trailer, he ran from the unit to obtain assistance. The fire from the pump eventually destroyed the trailer and spread to the adjacent warehouse. The liquid tank which was to be filled, although extensively damaged, remained upright and still contained liquid after the fire. The pump installation did not include an inlet screen. A large 2-1/2" long piece of soft solder was found in the inlet piping as well as a 2-3/4" long piece of 1/2" brass pipe. It is believed that the fire initiated inside the pump before rupture of the pump or piping occurred. Airco presented a list of 21 pump incidents, covering the years 1963 through 1970. Pertinent details from this listing are:

a. 12 incidents were caused by bearing failures,
b. 10 fires involved aluminum volutes and aluminum impellers,

c. 12 fires involved pump operating at speeds between 7200 and 15,800 rpm,

d. 11 fires occurred at speeds over 9500 rpm,

e. 13 fires occurred in Airco plants, 6 at customer locations, and 1 at a distributor location,

f. 1 failure was the result of a valve being installed backwards,

g. 1 failure involved a bearing housing explosion,

h. 3 incidents involved fires in belt housings and did not involve the presence or release of oxygen,

i. 2 fires occurred in graphite seals.

NCG, Airco and Linde are using RPM-5 on motor bearings. All have used, or investigated the use of, LOX compatible lubricants on bearings and have, because of lubricity and corrosion problems, gone back to RPM-5. The consensus seemed to be that it is more important to preserve the integrity of the bearing by the use of a good lubricant and to take appropriate design measures, such as flingers and shields, to keep possible oxygen leakage away from the bearing, rather than to use a LOX compatible lubricant that would not react if exposed to oxygen, but because of poor lubricity and corrosion resistance will result in short bearing life.

SUMMARY OF LOX PUMP FAILURES AS REPORTED BY COMMITTEE

Committee members submitted questionnaires reporting 38 incidents involving fires and/or major failures in liquid oxygen pumps. A summary of these reports is included.

Major causes of failure can be summarized as follows:

No. of Failures	Cause of Failure
14	Due to bearing failure on gear driven high speed pumps.
10	Due to faulty repair, operation and/or installation.
4	Contamination entering pump.
5	Seal rubs & fires.
1	Belt box fire due to seal leak.
4	Not certain
38 Total	

The summary also indicates that of the 38 accidents, 13 pumps were reported to have had no suction line strainer, and 7 more where there was uncertainty if strainers were installed. Assuming that all of these 20 pumps did not have strainers, the reported probable causes for these incidents were:

No. of Failures		Cause of Failure
2		Not certain (both gear driven - probably bearing failure and rub).
6		Bearing failure - alum/alum rub.
5		Faulty repair, installation and/or operation.
1		Belt box fire.
2		Seal fires.
4		Foreign contaminant (20%)
20	Total	

Where pump incidents occurred with strainers installed, the reported probable causes were other than foreign contaminant.

WLB/Safety Dept.
6/3/71

AIR PRODUCTS AND CHEMICALS, INC.

DRAWING 000-0-407004 E

MASTER DRAWING 1200 SERIES REGULATORS

DOCUMENT NOT AVAILABLE FOR GENERAL DISTRIBUTION

APCI DOCUMENT
NO. 99000308

. G. Frederick
. R. Atshaw
. McKinley
. W. Robinson

Air Products and Chemicals INC.

ANALYTICAL REPORT

DATE: 5/28/71
LAB. NO.: 71-264
LAB BOOK: 1620

SAMPLE OF: Johns-Manville Asbestos Sheet Packing
FROM: Style No. 61

SAMPLING DATE: REQUESTED BY: G. Robinson SAMPLED BY:
ANALYSIS REQUESTED: Compatibility of Material with Oxygen

ANALYTICAL METHOD: Combustion in Oxygen and Soxhlet Ether Extraction
ANALYST: IWO NO.: PROJ. NO.: R&D PROJ. NO.:
REMARKS: LB-0795

ANALYSIS

A piece of the Johns-Manville Asbestos Sheet was submitted to this lab to determine the compatibility of the material with oxygen. A test piece of Garlock 900 gasket material was also run at the same time for comparative results. The following tests were performed:

1. Ignition in an oxygen environment. Ignition of the Johns-Manville packing and the Garlock packing in a Schöniger flask containing a 100% oxygen atmosphere showed that both samples burned approximately 14 seconds with some charring of the sample and some discoloration. However, both samples were able to extinguish the flames before they were totally consumed.

2. Ether Extraction. The Johns-Manville packing was placed in a Soxhlet Extractor and extracted for 22 hours with 250 ml. of diethyl-ether. The results were compared to a previous extraction of the Garlock 900 packing. The following results were recorded for this experiment:

Sample	Samplt Wt. (grams)	Extracted Residue (grams)	Percent Ether Extractable Contaminants	Fluorescence
70-013 Garlock 900	7.94630	0.14720*	1.83	Negative
71-264 J-M Style No. 61	26.63760	0.23439**	0.878	Negative

Percent ether extractable contaminants was calculated by the following method:

$$\% = \frac{\text{Extracted Residue - Blank}}{\text{Sample Wt.}} \times 100$$

* The 250 ml. ether blank for sample 70-013 which was reported on 1/30/70 was 0.00206 grams. The previous report on this material is attached as a reference.

** 250 ml. ether blank = 0.00162 grams

APCI DOCUMENT ID 22000309

Conclusion: The data from the two experiments performed appear to indicate that the Johns-Manville Sheet Packing Style #61 is as good as or better than Garlock 900.

Prepared by Lowell G. Frederick
Lowell G. Frederick

Approved by David R. Latshaw
David R. Latshaw

LGF/plr

Attachment

Air Products and Chemicals INC.

INTER-OFFICE
MEMORANDUM

Date: June 2, 1971

Subject: LOX COMPATIBLE GASKET
MATERIALS

To: W. W. Schmoyer — Safety Department
(Location, Organization, or Department)

From: G. W. Robinson — Operations Department
(Location, Organization, or Department)

cc: L. Ball
J. M. Geist
D. R. Latshaw
H. H. Master
C. Mc Kinley
R. D. Paige
W. T. Rector
W. J. Scharle
E. P. Thomas

Attached are recent test reports issued by D. R. Latshaw in connection with tests performed on asbestos sheet packing material.

As you know, Garlock 900 and Durabla are the only sheet packing materials approved for gaskets in oxygen service.

From an economical and convenience basis, it would be advantageous to have other materials that can be used. Durabla is quite expensive and Garlock 900 is not always easily obtainable.

From the recent report on Johns Manville asbestos sheet packing, style #61, it appears that this material is "as good or better" than Garlock 900 for oxygen service. In addition, it will be more economical and availability will be good.

It is requested that this material be approved for oxygen service and made a part of our standards.

ORIGINAL SIGNED BY

G. W. Robinson

GWR:ss

Retyped 9/27/72 krs

APCI DOCUMENT NO. 990003/0

L. G. Frederick
D. R. Latshaw
C. McKinley
W. W. Schmoyer

Air Products and Chemicals INC.

ANALYTICAL REPORT

DATE: 1/30/70
LAB. NO.: See Below
LAB BOOK: 1374

SAMPLE OF: Gasket Materials
FROM: Safety Department

SAMPLING DATE: REQUESTED BY: SAMPLED BY:
ANALYSIS REQUESTED: Compatibility of gasket materials with oxygen

ANALYTICAL METHOD: Combustion in oxygen and Soxhlet ether extraction
ANALYST: L.G.F. IWO NO.: XD-0123 PROJ. NO.: R&D PROJ. NO.:
REMARKS:

ANALYSIS

Samples of gasket materials KM-226 and KM-246 were submitted to this lab in order to determine their compatibility with oxygen. It was also requested that these materials should be compared with garlock 900 gasket material. The following tests were performed.

1. Ignition in an oxygen environment - Ignition of the KM-226 and KM-246 materials in a Schöniger flask which contained 100% oxygen showed that both samples burned for approximately twenty seconds with considerable charring of the material. Under a similar test the Garlock 900 also burned for approximately twenty seconds with considerable charring of the sample.

2. Ether Extraction - Samples of KM-226, KM-246 and Garlock 900 were placed in separate Soxhlet Extractors and extracted for 22 hours with 250 ml. of diethyl ether. The following results were recorded for this experiment.

	Sample Wt. (grams)	Extracted Residue (grams)	Percent Ether Extractable Contaminants	Fluorescence
70-013 Garlock 900	7.94630	0.14720	1.83	Negative
70-014 KM-226	23.31190	0.63110	2.70	Negative
70-015 KM-246	7.71409	0.24067	3.09	Negative

250 ml. ether blank = 0.00206 grams

Percent ether extractable contaminants was calculated by the following formula:

$$\% = \frac{\text{Extracted Residue - Blank}}{\text{Sample Wt.}} \times 100$$

Air Products and Chemicals INC

DATE: 1/30/70
LAB No.: See Page 1
LAB BOOK: 1374
SAMPLE OF: Gasket Materials

Infrared spectra of the residue from the KM-226, KM-246 and Garlock 900 materials shows all the residues to be aliphatic hydrocarbons which are similar in structure.

Conclusion: Due to the ignition characteristics and the high percentage of ether extractable contaminants in all the materials, it must be concluded that none of the materials are completely compatible with oxygen. However, it does appear that the KM-226 and KM-246 are no worse than the Garlock 900.

ORIGINAL SIGNED BY

D. R. Latshaw

Retyped Second Page 9-27-72 krs

L. G. Frederick
F. K. Kitson
A. Lapin
D. R. Latshaw
C. McKinley
W. W. Schmoyer

Littlebook

Air Products and Chemicals INC.

ANALYTICAL REPORT

DATE: 7/15/71
LAB. NO.:

SAMPLE OF: Various Lubricating Oils
FROM:

SAMPLING DATE: REQUESTED BY: A. Lapin SAMPLED BY:
ANALYSIS REQUESTED: Fluorescence of Various Types of Oils

ANALYTICAL METHOD: Ultra Violet Light
ANALYST: L.G.F. IWO NO.: PROJ. NO.: R&D PROJ. NO.:
REMARKS:

ANALYSIS

In order to get an idea of the detectable level of fluorescence for various oils, the following experiment was performed.

One droplet of oil was placed in a pre-weighed 250 ml. beaker. The oil was then weighed, diluted with approximately 25 ml. methylene chloride, and placed on a steam bath. The solvent was evaporated to dryness so that a film of oil remained at the bottom of the beaker. The oil film was then subjected to ultra violet light to determine the intensity of fluorescence. Listed below are the results of the above tests.

Type Oil	Sample Wt./Area	Fluorescence
Mobil DTE 105	0.0070 g./3.96 $in.^2$ or 0.255 g./$ft.^2$	Strong positive - blue
Texaco Cappella AA	0.0145 g./3.96 $in.^2$ or 0.528 g./$ft.^2$	Negative
Cellulube 550	0.0235 g./3.96 $in.^2$ or 0.855 g./$ft.^2$	Negative
Fluorolube	0.0222 g./3.96 $in.^2$ or 0.808 g./$ft.^2$	Negative
Sears Thread Cutting Oil	0.0190 g./3.96 $in.^2$ or 0.691 g./$ft.^2$	Strong positive - blue

Sears thread cutting oil is a hydrocarbon oil containing ester groups.
Mobil and Texaco oils are both hydrocarbon oils.
Cellulube oil contains aromatic groups and is known to contain triaryl phosphate groups.
Fluorolube oil contains carbon fluorine bonds.

Remarks: This experiment was not performed in order to determine the lowest detectable fluorescence level for each oil. Rather, it was performed to give a visual demonstration for those involved as to which oils fluoresce and which oils do not fluoresce when applied as a thin film. The reason the Mobil and the Sears thread cutting oils fluoresce and the others do not fluoresce is because there must be some additive added to these two oils which is capable of fluorescence.

Prepared by Lowell G. Frederick
Lowell G. Frederick

LGF/plr

DOCUMENT

L. G. Frederick
A. Lapin
D. R. Latshaw
A. J. Mahr
C. McKinley
W. Schmoyer
C. Stompler

LB

Air Products and Chemicals INC.

ANALYTICAL REPORT

DATE: 10/25/71
LAB. NO.: 71-446
LAB BOOK: 1739

SAMPLE OF: Epoxy Compound
FROM: Crest Products Co., 3010 Halladay St., Santa Ana, Calif.

SAMPLING DATE: REQUESTED BY: R. C. Stompler SAMPLED BY:
ANALYSIS REQUESTED: Oxygen compatability

ANALYTICAL METHOD: Oxygen Index
ANALYST: L.G.F. IWO NO.: PROJ. NO.: R&D PROJ. NO.:
REMARKS: XD-0134

ANALYSIS

A two-part epoxy compound (7343 Resin - 7139 Catalyst) from Crest Products Co. was submitted to this lab for testing. The sample was prepared according to the manufacturer's instructions and placed on various test panels to cure.

A portion of the epoxy was placed on a polyethylene sheet about 3 mm. thick, and later removed and cut into 6.5 mm. x 70 mm. strips for testing in the oxygen index apparatus. The following results were obtained:

% Oxygen	Remarks
30	Material melts when exposed to flame, no ignition occured
35	No ignition, melts
40	No ignition, melts
50	Entire test piece burst into flames, burns to completion in 20 seconds
45	Burns to completion in 20 seconds
42	Burns to completion in 20 seconds

The estimated n value (% oxygen needed to support combustion) is 41. The flame propagation down the test piece was extremely rapid in comparison to some of the plastic materials tested, i.e., polyethylene, p.v.c., etc.

Two brass panels coated on one side with the epoxy were subjected to liquid nitrogen temperatures. The one coating became loose, however, this may have been caused by inadequate surface preparation. The coatings were subjected to impact at -320° and showed no signs of stress.

Prepared by Lowell F. Frederick

Approved by David R. Latshaw

LGF:plr

APCI DOCUMENT NO. 9000342

Form 8029

L. G. Frederick
A. Lapin
D. R. Latshaw
A. J. Mahr
C. McKinley
W. W. Schmoyer

L/b

Air Products and Chemicals INC.

ANALYTICAL REPORT

DATE: 10/22/71
LAB. NO.: 71-336
LAB BOOK: 1739

SAMPLE OF: Oxy-Tite
FROM: Lake Chemical Co., 250 N. Washtenaw Ave., Chicago, Ill.

SAMPLING DATE: REQUESTED BY: A. Lapin SAMPLED BY:
ANALYSIS REQUESTED:

ANALYTICAL METHOD: Oxygen Index
ANALYST: L.G.F. WO NO.: XB-0134 PROJ. NO.: R&D PROJ. NO.:
REMARKS:

ANALYSIS

A sample can of Oxy-Tite thread compound for oxygen systems was submitted to this lab to determine oxygen compatability. Some of the compound was spread on Whatman filter paper and another portion on a rigid plastic sheet.

After several days, some of the compound that was placed on the filter paper was ignited in room air and appeared to burn quite well. The compound was then allowed to dry for approximately five to six additional weeks. The compound still remained in the same consistency it had been when removed from the can.

A portion was removed from the plastic sheet and placed on teflon strips for testing in the oxygen index apparatus. Teflon was used because of its high oxygen index value (90-95). The following results were obtained:

% Oxygen	Burning Time (Sec.)	Remarks
25	-	Chars - self-extinguishing
34	3	Chars - self-extinguishing, a few ambers burned for 3 sec.
50	20	Chars - self-extinguishing, ambers burn for 20 sec.
80	20	There appears to be some gaseous ignition from the surface of the sample. Sample still remains self-extinguishing
90	20	Sample burned about 25 mm. and went out. The burning that did occur was rather violent, and appeared to be gaseous combustion away from the sample surface.

Prepared by Lowell G. Frederick
Lowell G. Frederick

Approved by David R. Latshaw
David R. Latshaw

LGF:plr

Form 3029

APCI DOCUMENT NO. 22000342

Air Products and Chemicals INC.

INTER-OFFICE
MEMORANDUM

Date: June 22, 1971

Subject: Rupture Discs,
LOX Tankers

To: M. T. McHugh — Distribution and Fleet Operations
(Location, Organization, or Department)

From: F. K. Kitson — IGD Engineering
(Location, Organization, or Department)

cc: A. Lapin
P. C. Manwiller
P. F. Newman
W. W. Schmoyer
B. Trammell

This will confirm your question and my reply of June 21 regarding the acceptability of the rupture discs manufactured by Ametek as being sufficiently compatible with oxygen to eliminate any concern in safe operation of the LOX tankers presently in service due to the very small quantity of flammable adhesive on the disc. We seriously question if an adhesive is available which could be considered completely compatible with oxygen. Tests conducted at R&D on June 22 verify the fact that the small quantity of adhesive between the lead and aluminum sheets is insufficient to ignite the aluminum in an oxygen atmosphere.

As in any oxygen system, an evaluation of the degree of hazard depends on the combustibility of the material in oxygen and quantity present, the additional material which can enter into the reaction, if a triggering mechanism is present, and the total consequences that can conceivably occur. The stainless steel piping and vent stack, copper on older tankers, discharging to the atmosphere further reduce the possibility of a safety problem.

Paul Manwiller indicates discs are supplied by three other manufacturers under Spec. 93879A. Samples of these discs will be reviewed and if judged advisable, tests will be conducted at R&D.

If you have any further questions, please contact me.

ORIGINAL SIGNED BY

F. K. Kitson

FKK:nb

Retyped 9-27-72 krs

[320]

APCI DOCUMENT NO. 93879A

Air Products and Chemicals INC.

SAFETY RELIEF DEVICE STANDARDS

by

Compressed Gas Association, Inc.

PART III

Compressed Gas Storage
Containers

CGA Pamphlet S-1.3
11P, 1966.

APCI DOCUMENT
NO. 22668

EYE PROTECTION

1. PURPOSE

This standard establishes approved eye protection equipment and purchasing data for all employees working in areas where eye protection has been declared necessary.

2. SCOPE

This standard applies to all APCI facilities.

3. GENERAL

This standard governs unless supplimented or superseded by the "Recommended Safety Equipment List" prepared by APCI Safety Department for each installation. Any changes to this standard require approval by the Safety Department.

All of the listed vendors have offices in major cities throughout the United States and overseas. Should none of these vendors be available, any company with equal specifications will be acceptable.

4. SPECTACLE TYPE (CORRECTIVE OR NON-CORRECTIVE) CLEAR AND TINTED

A. Areas of Use

Low impact areas where the hazard of flying materials is at a minimum. This type of protection is to be classified as a minimum for eye protection. The tinted lens should not be used as a substitute lens for welding work.



B. Description

1. Clear hardened glass meeting American Standards Association standard (includes hardning, impact test of 0.4122 foot pounds, minimum thickness, optical correctness, etc.). Frames are to be of flesh color plastic unless otherwise approved by the facility authority. Temples are to be of either the "Comfort Cable" type or the flat spatula.

2. Tinted hardened lenses in various shades of tint, to American Standards Association specifications. Available in prescription or non-corrective plano lenses. Frames are to be of flesh color plastic unless otherwise approved by the facility authority. Temples to be of the "Comfort Cable" type or the flat spatula.

APCI DOCUMENT NO. 22000.16

Air Products ...INCORPORATED	Originated By: H. W. Smith	Approved: Safety Director W. L. Ball	Date October 1962

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EYE PROTECTION

4. SPECTACLE TYPE (CORRECTIVE OR NON-CORRECTIVE) CLEAR AND TINTED (Contd)

B. Description (Contd)

2. (contd)

Tints available are "Calobar" medium, dark, extra dark, and Didymium. The following table will govern the use of tinted lenses:

Calobar Shades	Visible Light Transmitted	Ultraviolet Absorbed	Infrared Absorbed
Medium	53%	100%	80%
Dark	35%	100%	92%
Extra Dark	20%	100%	95%

Didymimum lenses absorb about 90 per cent of yellow sodium flare encountered in glass blowing.

C. Vendors - American Optical Company
Bausch & Lomb Optical Company
Industrial Products Company
Titmus Optical Company
Willson Products Company

5. EYE SHIELD TYPE

A. Areas of Use

As a visitor eye protection item, or to be used until prescription spectacles are available. These visor type shields are not to be used as a substitute for spectacle type eye protection in areas of production hazards.



B. Description

One piece plastic lens with either plastic spatula temples or elastic headband. Universal size and fits over personal spectacles.

C. Vendors - American Optical Company
Bausch & Lomb Optical Company
H. L. Bouton Company
Industrial Products Company
Willson Products Company

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EYE PROTECTION

6. FACE SHIELDS



A. Areas of Use

Used for situations where not merely the eyes, but the whole face requires protection. The use of face shields does not eliminate the use of spectacle type protection, but is used in addition to other protection.

B. Description

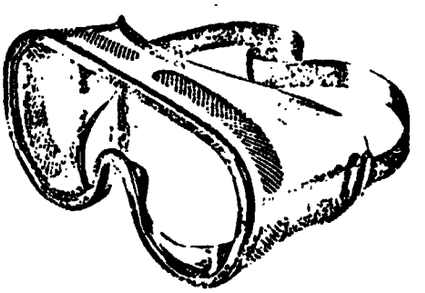
The assembly consists of a headgear and visor. The headgear provides for support of weight by crown strap and has hard fiber spark-guard protecting the forehead. Size adjustment is made by a single knob in the back, and a thumb-nut adjustment is provided for visor position. The visor is clear and is 9 inches by 19 inches by .060 inches.

C. Vendors -

American Optical Company
Fibre-Metal Company
Industrial Products Company
Mine Safety Appliance Company
Willson Products Company

7. MONOGOGGLE TYPE

A. Areas of Use



The unvented type are designed to be used in areas where acids or alkalis could be splashed in the eyes. The vented type are to be used where moderate impact is involved, and where small flying material might get behind the spectacle type glasses.

B. Description

Soft plastic, close fitting clear frame with one piece, optically correct, clear plastic lens and elastic headband. Universal size, can be worn over personal glasses.

C. Vendors -

American Optical Company
Bausch & Lomb Optical Company
H. L. Bouton Company
Industrial Products Company

Air Products INCORPORATED	Originated By: H. W. Smith	Approved: Safety Director W. L. Ball	Date October 1962

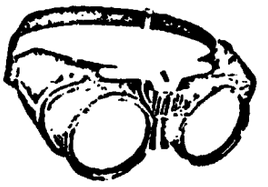
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EYE PROTECTION

7. MONOGOGGLE TYPE (Contd)

C. Vendors - (Contd) - Mine Safety Appliance Company
Willson Products Company

8. CHIPPER'S GOGGLES



A. Area of Use

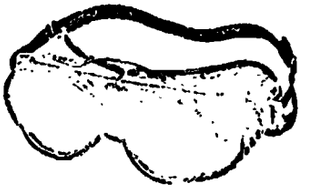
Used for protection against impact as in chipping, grinding, etc.

B. Description

Soft clear vinylite frame with high impact resistant clear plastic lenses adapter and 50 mm clear safety lenses. The frame may be perforated to prevent fogging. Universal size; can be worn over personal glasses.

C. Vendors - American Optical Company
Bausch & Lomb Optical Company
H. L. Bouton Company
Industrial Products Company
Willson Products Company

9. WELDER'S GOGGLES



A. Areas of Use

Used for acetylene welding, cutting, burning, brazing, etc. Protects against injurious light rays, glare, flying sparks, chips and scales.

B. Description

Opaque green soft vinyl frame with black flame resistant plastic lens adapter and 50 mm lenses of the proper shade.

Guide to Shade Numbers

1.	Soldering	shade 4
2.	Acetylene cutting (up to 6 in.)	shade 4
3.	Acetylene cutting (6 in. and over)	shade 6
4.	Acetylene welding (up to 1/8 in.)	shade 4
5.	Acetylene welding (1/8 in. and over)	shade 6
6.	Electric arc welding	use welding hood
7.	Inert gas welding	use welding hood

NOTE - Universal size - can be worn over personal glasses.

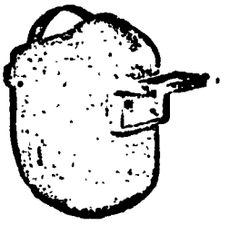
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EYE PROTECTION

9. WELDER'S GOGGLES (Contd)

C. Vendors - American Optical Company
Bausch & Lomb Optical Company
H. L. Bouton Company
Industrial Products Company
Willson Products Company

10. WELDING HOODS



A. Areas of Use

Electric arc welding and cutting, inert gas welding.

B. Description

Full curve lift front welding helmet (vulcanized fiber or fiber glass) equipped with the proper shade filter glass and a clear glass cover plate in a lift-front holder. Universal fit - adjustable.

Shades of Filter Glasses

1. Shade number 10 is to be used for electrical arc welding and cutting using current values up to 200 amperes.
2. Shade number 12 is to be used for electrical arc welding and cutting using current values from 200 to 400 amperes.
3. Shade number 14 is to be used for electrical arc welding and cutting, inert gas welding, carbon arc welding and cutting and for atomic hydrogen welding using current values over 400 amperes.

NOTE - It is recommended that safety spectacles be worn under welding helmets.

C. Vendors - American Optical Company
Fibre-Metal Products Company
Industrial Products Company
Mine Safety Appliance Company
Willson Products Company

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SAFETY - GRAM

Air Products and Chemicals INC.

June 1, 1961
No. 1

PRESSURE GAUGE FAILURE

Safety Glasses Save Another Pair of Eyes

Safety glasses undoubtedly saved another pair of eyes last Monday morning when a pressure gauge failed, blowing fine splinters of glass into the face of one of the operators. The lenses of the safety glasses were chipped by the impact of the flying splinters, and the operator spent 24 hours in the hospital after having the splinters removed from his face--but his eyes were unscathed.

The unit that failed was an Ashcroft three thousand pound test gauge certified for oxygen service. Although the gauge had been in service less than two months, it had been used on a number of occasions in oxygen service at the new Granite City plant. At the time of the failure, the gauge was being used to check the pressure gauges in the cylinder filling room. To check the manifold pressure gauge, the test gauge had been connected directly to an oxygen cylinder which had just been filled to about 2400 psig. When the cylinder valve was opened, the Bourdon element failed, breaking the cast aluminum case into four large pieces and numerous small ones, and shattering the safety glass crystal. Although the blowout grommet released, there was not sufficient area to relieve the high pressure and high flow of gas from the cylinder without breaking the case and the crystal. One operator received a severe sprain of the left hand, and a cut on the forehead, but was released from the hospital after X-ray and treatment. The second operator, however, was standing in front of the gauge at the time it failed, and was struck in the face by splinters from the safety glass crystal.

Engineering specifications for some time have called for solid front construction and plastic crystals for all pressure gauges 4½ inches in diameter and larger, except 3 to 15 psi receiver gauges. The entire back of a solid front gauge will blow out at a very low internal pressure. The plastic crystal adds to the safety of the unit, as it is stronger and will not shatter as will both plain and safety glass. It should be noted by all requisitioning offices that this type of construction is required.

In addition, the following precautions should be followed:

- Pressure gauges should be installed, if possible, above eye level.
- Gauges should be pressurized slowly. Pressure surges may rupture the gauge or, if in oxygen service, may ignite combustibles in the Bourdon element if the unit has not been cleaned or handled properly.
- Safety glasses must be worn in all areas designated as requiring safety glasses.

APCI DOCUMENT NO. 19000372

SAFETY - GRAM

Air Products and Chemicals INC.

August 1, 1963
Number 29

Safety Equipment Never Prevents an Accident-- It only Prevents an Injury

The following has been extracted from a report by H. W. Keys, Safety Engineer, West Coast Operations:

> "On June 19, 1963 a loader at Vandenberg AFB had just finished loading a liquid nitrogen trailer; the valves were shut off and the loader was waiting for the liquid in the transfer hose to vaporize. At this moment, the Air Force driver opened the valve and started to disconnect the transfer hose. Liquid nitrogen sprayed out of the valves and a large volume of liquid struck the loaders face shield. This liquid caused the face shield to freeze; the loader turned away and struck the face shield on a steel beam causing it to shatter. Should this loader have not been wearing his face shield, he could have been blinded and would have suffered extensive tissue damage."

Many times APCI personnel have been observed handling cryogenic liquids and materials without any of the prescribed personnel protective equipment. These persons are placing themselves in a position where even a minor spill could cause a very severe injury. Persons handling cryogenic materials, whether it be in plant operations, customer delivery, manufacturing applications or in the laboratory should re-evaluate their handling procedures and observe the following recommendations:

1. A full face shield should be worn over the usual safety glasses.

2. Gloves should be worn with the gauntlets tucked under the cuffs of the shirt or coat.

3. Be sure that drivers know and follow the trailer loading procedures; make certain that all others handling cryogenic materials are familiar with the safe handling procedures and wear the proper protective equipment.

4. Before disconnecting any transfer hose, be sure that the liquid has been drained, any remainder vaporized and the hose has been depressurized.

There is a safety axiom that Bill Keys included in his report which is appropriate: "Safety equipment never prevents an accident; it only prevents an injury." Using this approach, we must endeavor to eliminate unsafe handling practices, and back this up with the wearing of proper protective equipment.

SAFETY DEPARTMENT
HWSmith/jmf

APCI DOCUMENT 2000418

SAFETY - GRAM

Air Products and Chemicals INC.

March 15, 1967
Number 58

AND THEN THERE WAS DARKNESS

An employee is now blind in one eye and vision is impaired in the other eye as a result of a test gauge failure while an oxygen cylinder was being checked for pressure content.

The cause of the gauge failure, which is not known at this time, is not significant so far as this accident is concerned. The important fact is that serious injury was involved because two safety rules were not followed. The injured person WAS NOT WEARING SAFETY EYE GLASSES and WAS STANDING DIRECTLY IN FRONT OF THE GAUGE WHEN IT WAS PRESSURIZED. These injuries were completely avoidable and unnecessary. If safety eye glasses had been worn and the proper procedure for using hand gauges to obtain pressure readings had been followed, no serious injuries could have occurred.

Each employee is responsible for his safe working habits, but it is the supervisors' and managers' responsibility to provide the necessary information to the employee so that he can perform safely, and to be constantly alert to prevent violations of safe work practices. Most importantly, supervisors and managers must set the pattern for safe practices by their own example.

Twelve accidents are on record concerning gauge failures, line failures, pressure failures, and other type industrial failures which have one very important item in common----"Safety glasses have saved the operator's eyes."

One safety rule is restated from the Company's Safety Policy,

> "Wearing of safety glasses in all work areas of the Company, with the exception of offices, rest rooms, locker rooms, and occupancies or similar nature, is mandatory."

YOU CAN REPLACE SAFETY EYE GLASSES, BUT YOU CANNOT REPLACE EYES.

WWSchmoyer/jg
SAFETY DEPARTMENT

APCI DOCUMENT NO. 99.002.3/2

WEARING APPAREL HARD HATS

1. PURPOSE

This standard establishes approved head protection for both electrical and non-electrical use.

2. SCOPE

This standard applies to all APCI facilities.

3. GENERAL

The following approved and standardized head protection is required on all purchases following the date of this standard. This standard governs unless supplemented or superseded by the "Recommended Safety Equipment List" prepared by the APCI Safety Department for each installation. Any change to this standard requires approval by the Safety Department.

4. NON-ELECTRICAL HARD HATS

White linear polyethylene. Hats must pass all federal dielectric, impact, and plumb bob tests. Hats will be equipped with dihedral suspension headband assembly in vinyl. Bullard No. 70-802 DM.

Vendor:
Industrial Products Company, 2820 North Fourth Street,
Philadelphia, Pa. 19133

5. ELECTRICAL HARD HATS

Yellow, estherene (2) plastic, passing the Edison Electric Institute requirements. Hats will be equipped with non-conductive plastic clips to hold the dihedral suspension headband assembly. Vinyl sweatband and non-conducting chin strap. Bullard No. E S-302 DM.

Vendor:
Industrial Products Company, 2820 North Fourth Street,
Philadelphia, Pa. 19133

6. HARD CAP WINTER LINERS

Green standard earlap winter liner - Bullard No. 70-EL-33 sizes:
small - 6-5/8 to 6-7/8
medium - 7 to 7-1/4
large - 7-3/8 to 7-3/4

Vendor:
Industrial Products Company, 2820 North Fourth Street,
Philadelphia, Pa. 19133

APCI DOCUMENT NO. 22000320

Air Products and Chemicals

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Date
Revised
June 15, [illegible]